STRUCTURAL INTEGRITY MANAGEMENT (SIM) FOR FIXED OFFSHORE PLATFORM

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CIVIL ENGINEERING

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Structural Integrity Management (SIM) for Fixed Offshore Platform

by

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CERTIFICATION OF APPROVAL

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Approved by,

Narayanan

(Associate Professor Dr. Narayanan Sambu Potty)

UNIVERSITI TEKNOLOGI PETRONAS

TRONOH, PERAK

January 2009

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

KABIR AKRAM

Mohammad Kabir Bin Mohd Akram

ABSTRACT

Malaysia has almost 175 fixed offshore platforms for petroleum production. Many of these are 25 years old and above. Hence, Structural Integrity Management (SIM) is important for Malaysia. In this study, the main objectives are to compare the current practices of SIM worldwide, understand the effects of extreme conditions to fixed offshore structures, obtain Malaysia fixed offshore platform characteristics data and lastly to produce a SIM manual for fixed offshore structures in Malaysia.

Structural Integrity Management (SIM) has been established in the Gulf of Mexico (GoM) and North Sea. However, there is no SIM framework or process to cater for Malaysian conditions. Therefore a SIM manual for fixed offshore structure management would greatly benefit all Malaysian oil and gas operators. This thesis evaluates the fixed jacket structure of an offshore platform only. Other structural parts such as foundations are not in this scope of study. Besides that, other major hazards such as earthquake, boat impact and corrosion rate are outside of the scope of this thesis.

The aim of this study is to propose a Petronas Technical Specification Structural Integrity Management (PTS-SIM) recommended practice. Therefore the methodology of the work must have the following aspect 1) Literature review, 2) Interview, 3) Data gathering, 4) Evaluation, 5) Strategy, 6) Program and 7) Development of PTS-SIM.

A case study was also conducted on Semarang-A (SMG-A) platform. SMG-A is a 26 year old platform in Sabah Operation (SBO). During the study, it was discovered that there was a gap in SMG-A inspection program. Prior to that, during the data gathering process, it was clear that most of the data was missing and scattered. Recommendations were given to close the gaps that were found in this study.

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I would also like to thank the PETRONAS Structural Integrity Management System (SIMS) project team members for providing me with the necessary computer programs and their office for this research. Most of the data that is used in this research was contributed by the SIMS project team and I am grateful for their cooperation and understanding in order to make this research a success.

I would also like to acknowledge Mr. Hugh S. Westlake, American Petroleum Institute (API) member and author for his valuable theoretical inputs and guidance in this research. Besides that, Mr. Yusoff Tapri of ATKINS has provided me with trainings and tutorials in understanding the Structural Integrity Management System (SIMS) framework that is currently being used by PETRONAS.

Finally, I would like to thank my family for supporting me in this work.

The opinion expressed in this document is those of the authors, and they should not be construed as reflecting the views of PETRONAS.

ACRONYMS

AIM	Assessment, Inspection and Maintenance
AIMS	Asset Integrity Management
API	American Petroleum Institute
GOM	Gulf of Mexico
IM	Integrity Management
ISO	International Standard Organization
JIP	Joint Industry Practice
MMS	Mineral Management Services
NDT	Non Destructive Test
NTL	Notice to Lessees
PCSB	Petronas Carigali Sdn Bhd
PMO	Peninsular Malaysia Operation
RBI	Risk Based Inspection
RP	Recommended Practice
SBO	Sabah Operation
SKO	Sarawak Operation
SNS	Southern North Sea
SOW	Scope of Work

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CHAPTER 1:

INTRODUCTION

1.1 Background of Project

Structural Integrity Management (SIM) is a continuous assessment process applied throughout design, construction, operations, and maintenance and decommissioning to assure that the structures are managed safely. The objective of the SIM process is to confirm that the structures are fit for purpose and maintain structural integrity throughout its life cycle and maybe longer. The SIM strategy will reflect the risk associated with the fixed platform. Where the risk is higher, the greater will be the rigor of the integrity management (IM) strategy and the robustness of the implementation program.

The primary objective of SIM is to provide a framework to ensure the continued fitness-for-purpose of offshore structures. The SIM process is applicable to all offshore structures including fixed, floating, and subsea facilities fabricated in steel, other metals or concrete.

1.2 Problem Statement

Structural Integrity Management (SIM) has been established in the Gulf of Mexico (GoM) and North Sea. However, there is no SIM framework or process to cater for Malaysian conditions. Therefore a SIM manual for fixed offshore structure management would greatly benefit all Malaysian oil and gas operators. This is because PETRONAS currently operates one hundred and seventy five (175) platforms offshore Malaysia and there is no a standalone PETRONAS Technical Specification (PTS)-SIM guide PETRONAS in its structural integrity management.

1.3 Objectives

The main objectives of this study are:

- Compare the current practices of SIM worldwide.
- To understand the effects of extreme conditions to fixed offshore structures.
- To obtain Malaysia fixed offshore platform characteristics data.
- To produce a SIM manual for fixed offshore structures in Malaysia.

1.4 Scope of Study

This thesis evaluates the fixed jacket structure of an offshore platform only. Other structural parts such as foundations are not in this scope of study. Besides that, other major hazards such as earthquake, boat impact and corrosion rate are outside of the scope of this thesis. Earthquake loading and boat impact loading may be governing for some structures. However, earthquake loading and boat impact are not studied and definite conclusions on such hazards cannot be made based upon this thesis. Corrosion will definitely be an important hazard for the structure but this aspect would need a specific investigation to evaluate the impact it has on the structural integrity of a platform.

CHAPTER 2:

LITERATURE REVIEW

2.1 Introduction

Past works done regarding Structural Integrity Management (SIM) are reviewed, summarized and comment on it based on the understanding achieved. Furthermore it identifies the knowledge gap in this particular topic and the problem statement for this final year project.

This literature review is organized into six (6) sub topics covering as given below:

1. Definition of a fixed offshore structure.
2. General overview of the oil and gas industry.
3. International codes.
4. Engineering Integrity Systems.
5. Recent natural disasters and impact on SIM.
6. Summary.

2.2 Definition of a fixed offshore structure

The structure shown in figure 2.1 is a fixed steel offshore platform. It forms the backbone of the offshore industry and there are in excess of 7000 such structures around the world. (Mather, 1995).

Figure 2.1: Fixed steel offshore platform

The most common type of offshore structures in service today is the jacket structure. The term jacket is derived from the function of the first offshore structures: to serve as guides for the piles that are driven into the soil to provide the foundation to the structure. The jacket is connected to the piles by welding off at the top. Hence the jacket carries no load from the topside and merely hangs from the top of the piles and provides lateral support to them e.g. against wave and wind loading. (Mather, 1995)

2.3 General overview of the Oil and Gas industry

The history of SIM can be traced way back nearly 60 years ago from the first fixed offshore platform that was installed in shallow water off the coast of Louisiana (in USA). Figure 2.2 shows the evolution of design process in fixed offshore platforms.

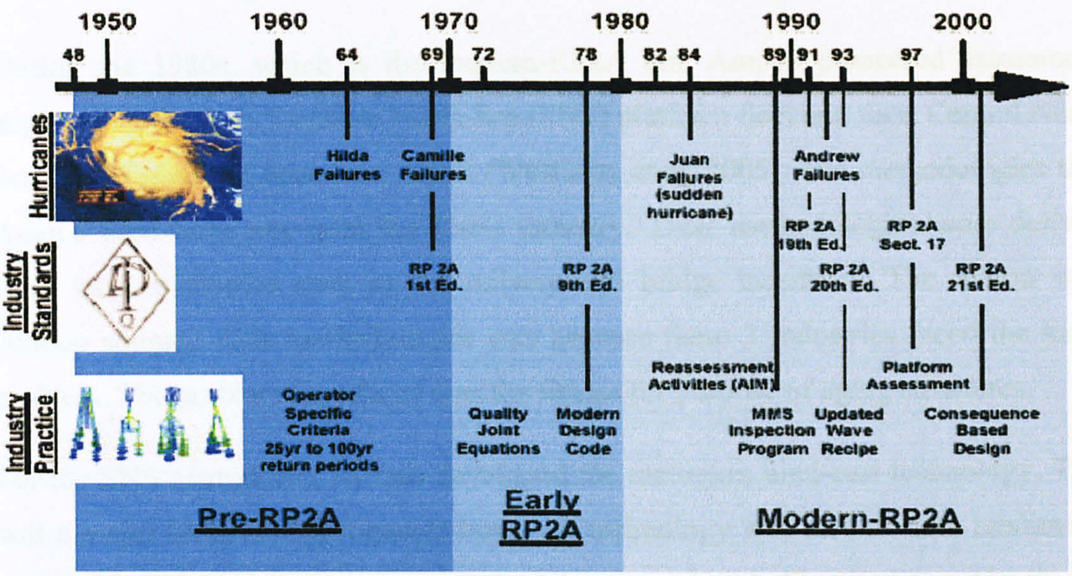

Figure 2.2: Evolution of Platform Design. (Westlake, et.al, 2005).

The first fixed offshore platform was installed in year 1948 in Louisiana (figure 2). Component design approach was used for its design. This approach has served the society well; indeed, experience from in-service performance suggest that well maintained platforms are more robust and damage tolerant than a component based design approach would indicate (Westlake, et.al, 2005). But most of these platforms have now exceeded their design life and are over 30 years old.

Because of this, in the early 1970s or so, engineers had to develop a new approach as an alternative to the component based design checks to ensure that their platform is fit for purpose and safe for use. As a result, new maintenance guidelines, assessment procedures were developed to better exploit the full capacity of offshore structures.

Assessment guidelines that were developed adopted the pseudo risk-based approach. This pseudo risk-based approach divided the platforms into risk categories, example high risk, medium risk and low risk. Besides that, it also considers the 'failure consequence' of the platform. This failure consequence has three main components which are environmental loss, monetary loss and injuries/safety related loss.

During this time, the O&G industry also robustly enhanced its capabilities by developing necessary technologies in order to gain the required confidence in the reliability of assessment practice. It led to an improved understanding of platform behavior in the harsh offshore environment and a gradual ability to better explain observed in-service performance. (Westlake, et.al, 2005).

During the 1980s, which is the modern-RP2A era, Amoco pioneered assessment engineering for their Southern North Sea (SNS) platform fleet and their Central North Sea (CNS) platform Montrose Alpha (Westlake, et.al, 2005). The methodologies that Amoco used were not from the O&G industry. Their methodologies were derived from other industries such as the railway and bridge industries. The reason why Amoco adopted their methodologies was because these 3 industries faced the same problem. The problem they faced was the fitness for purpose of aging structures.

For the SNS assessment, Amoco developed the metocean hind-cast technology. This was a major breakthrough because hind-cast technology was able to back predict the maximum wave height from measured environmental and climatic data. Also in the same period, Assessment, Inspection and Maintenance (AIM) Joint Industry Projects (JIP) were conducted for a variety of operators as well as Minerals Management Service (MMS) (Westlake, et.al, 2005).

The purpose of this project was to establish a framework for accessing and maintaining older platforms. These can be said to be the start of the SIM journey in the O&G industry. During the late 1980's, MMS developed an inspection program and during that same period it was clearly evident that an API process was required for assessing the structural integrity of existing jacket platforms. It was agreed that the approach should be different from the design of new platforms and a new section was establish which is the "API RP2A, Section 17 – Assessment of Existing Platforms".

After the successful development of "API RP2A, Section 17 – Assessment of Existing Platforms", many predicted that Section 17 would solve all the assessment problems regarding offshore platforms. But this was not the case, severe storms and hurricanes that hit the GOM severely tested the assessment process. From figure 2 it can be seen that 1992 was the year the hurricane Andrew occurred in the GOM.

After hurricane Andrew, significant findings were made from the application of integrity management and assessment engineering at that time. One of the findings was that all platforms that were damaged or failed were early vintage platforms of pre-1980 era. Platforms designed to RP2A standards in this era or to other standards (Pre-RP2A) are known to have certain design deficiencies', such as low decks, weak joints or poor framing configurations. (Westlake, et.al, 2005).

Furthermore, platforms that were designed to modern RP2A standards had no extensive damage or failures. Among platforms designed using Modern RP2A, the only one that was damaged was found to have been caused by construction error, and not design deficiency.

Recently the API subcommittee established a Task Group to develop a stand-alone Recommended Practice (RP) (Westlake, et.al, 2005) for the integrity management of fixed offshore structures. This new RP will include all the experience gained from many years of operational experience and technological developments. The main purpose of this RP is to provide guidance to owners, operators and engineers in the implementation and delivery of the SIM process. (Westlake, et.al, 2005).

As a summary it can be said that SIM is an important tool for an oil and gas operator to have. Although SIM are used in the GOM and North Sea, it has not been used yet in Malaysia. Furthermore, there is no SIM framework with respect to Malaysian conditions such as platform data, age, risk, types of facilities and etc.

Therefore it would be good if a SIM manual for Malaysia fixed offshore platform study is developed. This is to ensure that it meets the objective of SIM which is to make sure a structure is fit-for-purpose during its design life and sometimes longer. If a SIM for fixed offshore structure in Malaysia is developed, it would be a helpful to all the operators in this country

2.4 International codes.

Structural Integrity Management (SIM) is not a standalone process for the oil and gas industry. The main guiding principles of SIM are the International Standard Organization (ISO) and American Petroleum Institute (API) standards and recommended practices. Besides that SIM also exploits industry personnel expertise and know how to increase its reliability.

International Standards Organization (ISO)

ISO 19902-2004

Contains requirements for planning and engineering of the following tasks: design, fabrication, transportation and installation of new structures as well as their future removal; in-service inspection and integrity management of both new and existing structures; assessment of existing structures; evaluation of structures for reuse at different locations

American Petroleum Institute (API)

The American Petroleum Institute was incorporated in 1919 and is a trade company representing 200 companies which is involved in all the aspects in the oil and gas industry. The involvement of API in offshore structures was prompted by Hurricane Carla (1961), Hilda (1964) and Betsy (1965) which had caused damage to offshore platforms. (Mangiavacchi,*et. al.*, 2005).

The first edition on API RP2A was published in 1969 and three main areas of technology were initially identified which are environmental loads, foundations and tubular joints. The 7th edition of API RP2A was published in 1976 and proposed using the 100 year wave as a design condition. In 1993, the 20th edition of API RP2A was published and it recommended using the 100 year load conditions rather than the 100 year wave as design basis. The latest API RP2A that is currently being used was published in 1999. It is the 21st edition of API RP2A. (Mangiavacchi *et. al.* 2005).

API RP 2A Section 17: Assessment of Existing Platforms:

Provide a process of evaluating older, existing platforms to ensure that they are fit-for-purpose, including the use of metocean criteria that was lower than that for design of new platforms.

API RP 2SIM – Recommended practice for Structural Integrity Management:

Describes the SIM process and offer specific recommendations for in-service inspections, damage evaluation, structural assessment, assessment criteria, risk reduction and mitigation alternatives and, decommissioning of fixed offshore platforms.

2.5 Engineering Integrity systems.

2.5.1 Asset Integrity Management System (AIMS)

AIMS is an integrated management system that uses knowledge to manage the risk associated with physical assets. AIMS guide the organization into making and executing the decisions regarding the assets during each step of the asset's life cycle.

The implementation of AIMS brings a progression of change, where it actually enable employees to work within a set of clear, logical and well-defined processes for managing the physical assets essential to Petronas Carigali Sdn Bhd (PCSB) operations.

The AIMS requirements are organized around the Managing Elements, Functional Elements and Supporting Elements of the AIMS Framework, shown in figure 2.3:

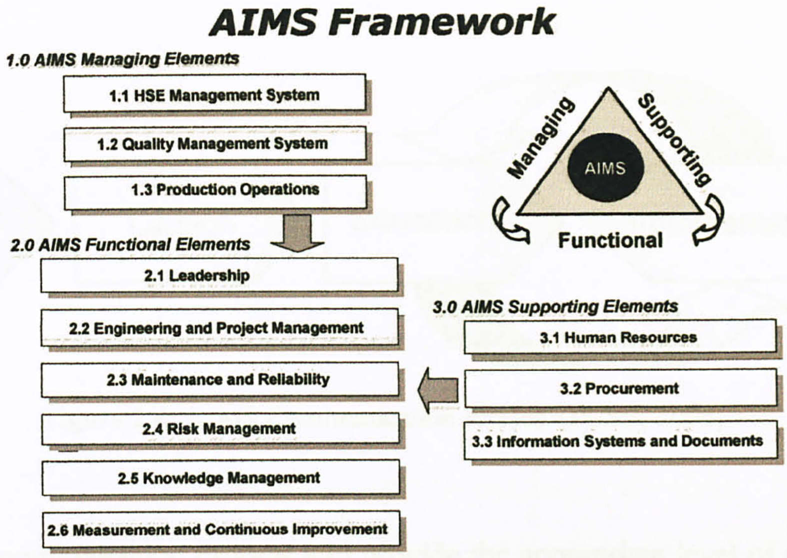

Figure 2.3: AIMS Framework. (PCSB, 2006)

The AIM System has been designed to manage the life cycle of the physical assets, with primary focus on the Design/Project Management and the Operation/Maintenance stages. Consequently the implementation of these projects will affect the PCSB personnel (including contractors) who are engaged in AIMS-related activities in all of the stages of the equipment lifecycle.

The AIMS implementation is designed to follow the Quality Process Model. Using that model will require identifying, mapping, documenting and improving the existing work processes that support AIMS.

To improve AIMS, PCSB has identified that communication between personnel in PCSB was lacking and therefore the organization identified communication as a key success factor in having a successful AIMS.

The AIMS Communication Plan describes the processes and products that will publicise AIMS throughout PCSB and aid in managing the AIMS-related changes. The four major steps of the AIMS Communication Process are: Awareness, Launch, Education and Implementation, illustrated in Figure 2.4.

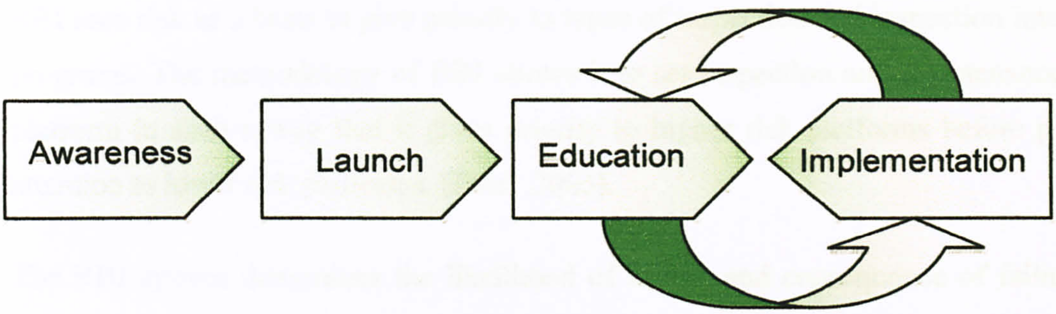

Figure 2.4: AIMS Communication Phases. (PCSB, 2006)

The AIMS Communication Process will provide the appropriate level of detail to the various personnel across the PCSB organization. The Education and Implementation steps will complement each other to create a continuing cycle of planning, implementation, measurement, and improvement, designed to support a world-class Asset Integrity Management System for PCSB.

Table 2.1: Comparison between the Traditional Maintenance Management System and the AIMS.

No	Traditional Maintenance Management System	Asset Integrity Management System
1.	Short to medium term perspective	Life-cycle
2.	Time based approach	Risk based approach
3.	Cost reduction	Cost Optimization
4.	Common engineering practices	World best practices
5.	Performance correction	Performance improvement

2.6 Risk Based Inspection (RBI)

In the oil and gas industry, there are two extremes type of inspections; unfortunately both are undesirable to the operators. One is that very little inspection is done. This is undesirable because less inspection would result in less platform information acquired. The second type of inspection is inspection is done very often. This is also undesirable because it involves cost. More inspection means higher cost. (Patel 2005).

American Petroleum Institute (API) has published a recommend practice for inspection intervals (API – 510).Unfortunately there is no logical method in determining when it can be done. (Patel ,2005).

RBI uses risk as a basis to give priority to types of inspection and inspection intervals programs. The methodology of RBI allows it to set inspection and maintenance to a platform in such a way that it gives priority to higher risk platforms before paying attention to lower risk platforms. (Patel ,2005).

The RBI system determines the likelihood of failure and consequence of failure. A risk is defined as:

Risk = Likelihood of Failure X Consequence of Failure

Likelihood of failure describes the failure per year and also the cause of failure of the structure. As for consequence, it touches on the number of fatalities, cost and to understand the failure mode. It groups a structure into High, Medium and Low inspection risk. Because of these groups, it can be easily decided which platform should be inspected first and which platform should be inspected last. (Patel ,2005).

The purpose of having this RBI is to identify which platforms is high risk, to design an inspection program and to manage the risk so that it doesn't fail. (Patel ,2005).

The RBI process consists of performing risk assessment of structure; determine inspection frequency and scope of work. The risk assessment is done to determine the current and anticipated condition of the platform.

It can be done by asking the following:

1. Rate of marine growth.
2. Rate of corrosion.
3. Scouring condition.

The summary of the RBI process showing each steps and inspection planning based on the risk analysis is shown in figure 2.5.

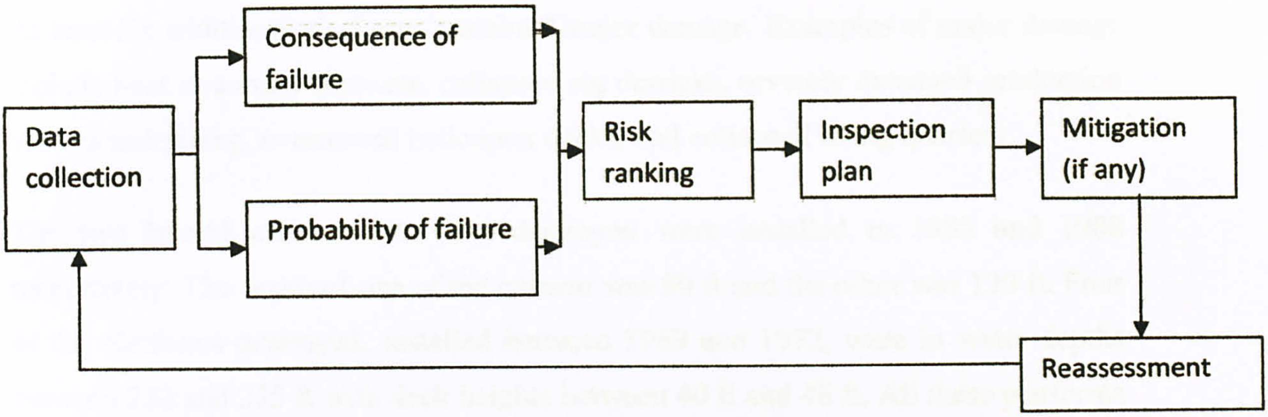

Figure 2.5: RBI process flow diagram. (Patel ,2006).

2.6 Recent general disasters and impact on SIM.

2.6.1 Hurricane Ivan

Hurricane Ivan was the strongest hurricane of the 2004 Atlantic hurricane season. Hurricane Ivan was formed on 2nd September 2004 and dissipated on 24th September 2004. The highest wind speed that was recorded during Hurricane Ivan was 270 km/h, passed on the north-northeast path striking the Florida-Alabama coast on Sept. 15, 2004. In its path there were 150 platforms and 10,000 miles of pipelines which were smashed by this hurricane.

At the peak of the storm, the data obtained by the National Data Buoy Centre recorded a significant wave height of 52.5 ft. Given the duration of the storm and a significant wave height of 52.5 ft, the maximum wave height was recorded at approximately 90 ft.

Seven structures were destroyed by Ivan, namely:

- Two braced caisson
- Four typical jacket structures in 250 ft of water
- One typical jacket structure in 479 ft of water

At least six additional platforms sustained major damage. Examples of major damage include bent structural supports, collapsed rig derricks, severely damaged production vessels and piping, overturned helicopter decks, and collapsed living quarters.

The two braced caisson that were destroyed were installed in 1985 and 1988 respectively. The depth of one of the caisson was 80 ft and the other was 120 ft. Four of the platforms destroyed, installed between 1969 and 1972, were in water depths between 232 and 255 ft with deck heights between 40 ft and 46 ft. All these platforms were designed based on the requirements of earlier editions of API RP 2A.

API released the fourth edition of its RP 2A in 1972. Analyst believed the failure of the eight-pile fixed platform installed in 1984 in 479 ft of water was due to mudslide movement in conjunction with the direct effects of Ivan. The intensity of the soil movement during Ivan exceeded expectations.

After Ivan, API set up a committee whose charge was to reorganize RP 2A. New platforms will continue to be addressed in API RP 2A. Those sections of the current edition of RP 2A associated with the assessment of existing platforms i.e. Section 17 of API RP2A will form the basis of a new API publication RP2 SIM (Structural Integrity Management).

In addition, API will remove some sections of RP 2A associated with specific design requirements, such as fire and blast, creating a third API standalone document. This reorganization will result in a risk management perspective in managing offshore platforms and also includes lesson learnt from Ivan.

2.6.2 Hurricane Rita and Katrina

Hurricane Katrina formed over the Bahamas on23rd August 2005, and crossed southern Florida as a moderate Category 1 hurricane, causing some deaths and flooding there before strengthening rapidly in the Gulf of Mexico. It was formed on 23rd August 2005 and dissipated on 30th August 2005. The highest wind speed that was recorded during hurricane Katrina was 280km/h.

Hurricane Rita was formed on 17th September 2005 and dissipated on 24th September 2005. The highest wind speed that was recorded during Rita was 285km/h. It was also the fourth-most intense Atlantic hurricane ever recorded and the most intense tropical cyclone ever observed in the Gulf of Mexico.

The consequence of Hurricane Katrina on structural integrity failure is devastating. The normal production in the Gulf of Mexico is 547.5 million barrels of oil and 3.65 trillion cubic feet of gas per year.

In preparation for Hurricane Katrina, 17.1 million barrels of oil and 84.2 billion cubic feet of gas were shut in. The production of oil in the Gulf of Mexico fell by 1.4 million barrels a day. This accounted for 95% of the daily production of oil. The equivalent of 3.4 billion cubic feet of natural gas per day was shut in. This is over 34% of the daily production of natural gas in the Gulf of Mexico. (McCaskill, 2006).

Two weeks after Hurricane Katrina struck the Gulf of Mexico over 120 oil and gas platforms were still shutdown. Nearly 60% of the gulf's daily production of oil and gas remained blocked from the market due to the evacuations of personnel in preparation for Hurricane Katrina. (McCaskill, 2006)

By September 11th, 21 oil refineries, a combined total of 47% of US distillates, were still not functioning. 11 of the 21 oil refineries were scheduled for operation during the next week. Six more of the refineries were scheduling operations within the next 30 days. The remaining four refineries all suffered serious damage.

None of them would be returning to full capacity by the end of the 2005. The refinery which sustained the most damage was actually the largest one. It required extensive rebuilding. The relighting and rebuilding processes would cause the US a deficit of 25% of the total supply. (McCaskill, 2006).

Figure 2.6 shows both the paths of Hurricane Rita and Katrina. The orange dots are denoting mobile rig locations and the grey dots are denoting all fixed manned platforms. Due to the combination of the more westerly path of Hurricane Rita and the width of Hurricane Katrina most of the 2900 platforms in the Gulf of Mexico were affected. (McCaskill, 2006).

By September 11th, 60% of off-shore oil production was working. The reports officially were that approximately 150 rigs were severely damaged though at least 500 of them were not inspected. 36 rigs were sunk and several were floating free, having broken moorings. (McCaskill, 2006).

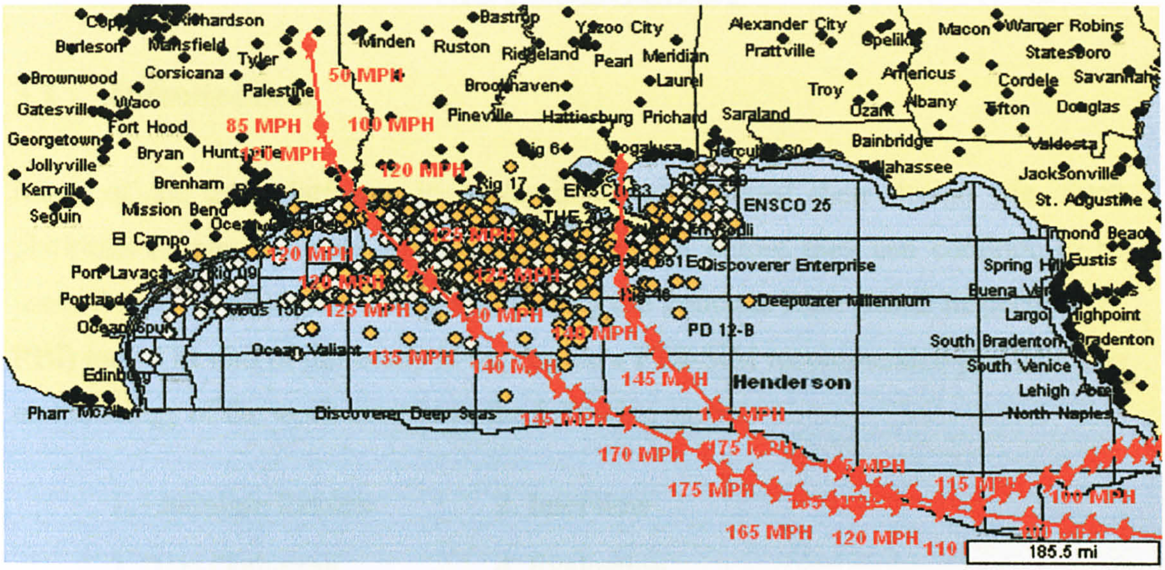

Figure 2.6: Path of Hurricane Rita and Katrina and location of fixed platform (McCaskill, 2006)

The impact of all these three hurricanes can be summarized in figure 2.7:

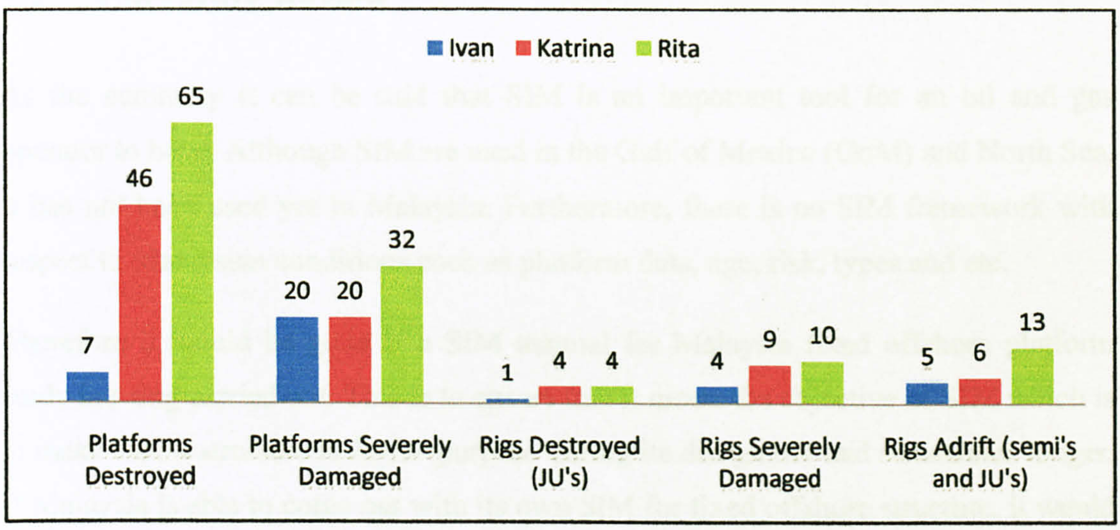

Figure 2.7: Summary of Hurricane damages due Ivan, Katrina and Rita

It can be observed that 118 offshore platforms were destroyed in the 3 hurricanes that were discussed above. The most costly hurricane that has hit the GoM is hurricane Rita. Hurricane Rita destroyed more platforms compared to hurricane Ivan and Katrina. Figure 2.7 shows that hurricane Rita destroyed 65 platforms compared to hurricane Ivan and Katrina which destroyed 46 and 7 platforms respectively.

CHAPTER 3:

METHODOLOGY

3.1 Introduction

Many of the 200 platforms in Malaysia have exceeded their design life. Such platforms require a fitness for purpose assessment before they can continue to be used. Generally platforms are assessed using the Petronas Risk Based Inspection (P-RBI) tool. The aim of this study is to propose a PTS-SIM recommended practice. The methodology of the work must have the following aspect:

1. Literature Review	2. Interview
3. Data Gathering	4. Evaluation
5. Strategy	6. Program
7. Development of PTS-SIM	8. Gantt Chart

3.2 Literature Review

As the summary it can be said that SIM is an important tool for an oil and gas operator to have. Although SIM are used in the Gulf of Mexico (GoM) and North Sea, it has not been used yet in Malaysia. Furthermore, there is no SIM framework with respect to Malaysian conditions such as platform data, age, risk, types and etc.

Therefore it would be good if a SIM manual for Malaysia fixed offshore platform study is being carried out. This is to ensure that it meets the objective of SIM which is to make sure a structure is fit-for-purpose during its design life and sometimes longer. If Malaysia is able to come out with its own SIM for fixed offshore structure, it would be a helpful to all the operators in this country.

The difference between AIMS and SIM is that AIMS is an Asset Integrity Management and caters for all of PCSB assets whereas SIM will only cater for the structural integrity of a platform. Besides that AIMS main objective is to manage the risk associated with physical assets whereas SIM is to manage the risk of structural integrity failure of offshore platforms.

Risk Based Inspection (RBI) has been carried out within Petronas Carigali Sdn Bhd (PCSB) and is a common practice with all the operators worldwide. The only differences are the conditions or the criteria that is being used by each operator to score its platforms. The score results basically would categorize a platform in 5 categories Very High Risk, High Risk, Medium Risk, Low Risk and Very Low Risk.

The inspection plans would then be tailored based on the category of each platform. RBI is important in Structural Integrity Management (SIM) because the data source for SIM is the RBI tool. Therefore this SIM study would include RBI as one of its main components to increase its reliability.

This study was conducted solely based on Malaysian waters with reference to GoM, North Sea and Petronas Risk Based Inspection (P-RBI) to identify the differences in approach. This is because in Malaysia jacket platform are the main oilrigs compared to GoM or North Sea where semi submersible, jack-up rigs, Gravity Based Structure (GBS) etc.

Therefore all this aspects was taken into consideration to ensure a good study is being carried out and a reliable SIM manual for Malaysian waters can be published.

3.3 Interviews

Interviews were conducted with industry specialist in the field of offshore engineering. Based on their experience in this field, four personnel were interviewed namely:

1. Mr. Minaz S. Lalani, ATKINS.
2. Mr. Hugh S. Westlake, ATKINS.
3. Mr. Nigel W. Nichols, PCSB.
4. Mr. Yusoff Tapri, ATKINS/SCIENTIGE.

The author chooses these four (4) personnel because of their credibility and vast experience in the field of offshore engineering. Mr. Minaz S. Lalani is the developer of Fleet Management System (FMS), which has a concept similar to SIM and is currently being used in Trinidad and Tobago for British Petroleum (BP) platforms.

Mr. Hugh S. Westlake, the author of American Petroleum Institute (API) SIM and also he is currently the consultant for PETRONAS Carigali Sdn. Bhd (PCSB) structural integrity management system (SIMS) project.

Mr. Nigel W. Nichols is the principal structural engineer for PCSB and has over 20 years of experience working in the oil and gas industry. Mr. Yusoff Tapri is the lead engineer for ATKINS/SCIENTIGE in the structural integrity management system (SIMS) project and has vast experience in Malaysia oil and gas industry with employment in various operators, consultants and also service companies.

3.4 Data gathering

Up-to-date platform data is a prerequisite for SIM data process. Information on the original design, fabrication and installation process, inspections, evaluations, structural assessment, Strengthening, modification and Repair (SMR) works which all constitute parts of the SIM knowledge base.

3.5 Evaluation

Evaluation of a fixed offshore platform is a continuous process and to ensure that it is fit for purpose. As additional data is collected, a qualified structural engineer would review and evaluate the data. Evaluation does not automatically imply a structural analysis. Evaluation can include engineering judgment based on specialist knowledge or operational experience, simplified analysis or reference to research data of similar platforms etc.

3.6 Strategy

Risk associated with structural deterioration are evaluated using periodic inspection to detect, measure and record significant anomalies. The fundamentals of this strategy are risk-based evaluation of a fixed offshore structure. The SIM strategy would define the planning of the inspection program. The plan includes frequency of inspection and scope of work (SOW).

3.7 Program

The program represents the execution of the detailed scope of work required to complete the activities defined in the SIM strategy. To complete the SIM process, all data collected during the SIM program must be fed back into the SIM data management system.

3.8 Development of PTS - SIM Code

The development of a PTS-SIM code would be a great benefit to Petronas. The PTS-SIM code would start off with the purpose of developing this code and the scope that would be covered. It has to be understood that the SIM process only covers the jacket structure of a platform. The SIM process consists of 1) Data gathering, 2) Evaluation, 3) Strategy and 4) Program.

Furthermore, the code would include what data that is needed to execute the first stage of the process. After execution of stage 1, the second stage will discuss the evaluation of the platform. This evaluation will be done based on the data received in stage 1. After that, stage 3 is the strategy. The strategy that would be undertaken is based on the evaluation result in stage 2. The strategy will cover types of inspection, inspection requirements and scope of work. The last stage will be the program where it would touch on how to reduce the platform risk and implementation of scope of work.

3.9 Gantt Chart

The Gantt chart refers to this final year project schedule. The author has developed this schedule to ensure that proper planning is done prior to the start of this project. This is to ensure that the project is completed on time without any delays. Summary of project Gantt Chart can be referred to Appendix 5.

CHAPTER 4:

RESULTS AND DISCUSSION

4.1 Introduction

The aim of this research is to be able to carry out a structured and comprehensive study of structural integrity management (SIM) operations and to come out with a manual of how to manage a fixed offshore platform in Malaysian waters. The findings of this study is reported and discussed below.

4.2 Outline for Structural Integrity Management (SIM)

Table 4.1 below shows the proposed SIM outline that would be discussed in this research. The SIM outline consists of four (4) main processes which are 1) Data, 2) Evaluation, 3) Strategy and 4) Program. These four (4) main processes and its sub-processes will be discussed more in this chapter.

Table 4.1: SIM proposed outline

1. **Data**	Characteristic	3. **Strategy**	Long term plan
	Yearly Inspection		Scope of Work definition
	Assessment		Decommissioning Schedule
	Data Management	4. **Program**	Routine Inspection
2. **Evaluation**	Risk Ranking		
	Damage Evaluation		
	Inspection trends		

4.3 Characteristic

The characteristic of platforms is important because it gives details on the structure. The details that are provided in this section are:

1. Platform details
2. Generic details
3. Operational details

Summary of platform characteristic data can be referred to Appendix 1.

4.3.1 Platform details

It is important to include this following criteria or information about platforms for the purpose of structural integrity management (SIM). The engineer that has been assigned to perform SIM has to get all the required data's either from the consultant, fabricators or project team. The data that is required are shown in table 4.2.

Table 4.2: Platform details

Platform details	1. Platform Name	6. Operational status	11. Sold or salvaged
	2. Field	7. Installation method	12. Reuse candidate
	3. Platform Type	8. Year/date of installation	13. Orientation of platform
	4. Platform function	9. No in complex	14. Latitude
	5. Heritage	10. Linked platforms	1. Longitude

<u>Platform Name</u>

Platform name is basically the ID of a platform. All the platforms in the world have a platform name. Furthermore, platform name is closely linked with the oilfield that it is situated. For example the Pulai oilfield, the platforms are named Pulai A and Pulai B respectively.

<u>Field</u>

Field is basically the oilfield from which oil is being extracted. Currently in Malaysia there are about 35 oilfields. For example some oilfields in Malaysia are Pulai, Duyong and Dulang.

<u>Platform type</u>

For fixed offshore platform, the most common platform used is the jacket leg platform. In Malaysia there are currently 175 jacket leg platform operated by Petronas Carigali Sdn Bhd. (PCSB).

Platform function

The usage of a platform is dependent on its function. The function of a platform can be divided into 10 categories. These 10 categories are shown in table 4.3.

Table 4.3: Platform function

Platform function	1. Wellhead	2. Drilling	3. Drilling and production
	4. Production	5. Quarters	6. Mini production
	7. Compression	8. Flare	9. Riser
	10. Vent		

Currently, as of today, based on interviews conducted with Petronas staffs, there are 40 wellhead platforms, 40 drilling platforms, 4 drilling and production platforms, 35 production platforms, 6 living quarters, 2 mini production platforms, 13 compression platforms, 3 flare platforms, 3 riser platforms and 17 vents platforms.

Heritage

Since Petronas was incorporated in 1973, most of their platforms were operated by foreign oil companies such as Shell and Exxon Mobil. This is because they did not have the technology to operate their own platforms. But after the set up of Petronas Carigali Sdn Bhd in 1978, most of the platforms were handed back to PCSB for operation. Therefore if a platform is handed back to PCSB from a foreign oil company, it has to be stated in the heritage column the previous operators of the platform. For example if the previous operators were Shell, then in the heritage column, the name Shell has to be recorded.

Operational status

Operational status of a platform describes whether the platform is active or non active.

Installation method

Installation method describes the method used to install the platform at its site. This document can be obtained from the fabricators. This is because most fabricators are also involved in the installation process of a platform that they had constructed. For instance Kenchana HL Fabricators are also involved in the installation process of the platforms that they had constructed.

Year/Date of installation

The year and date of installation is crucial because it determines the age of the platform and the date gives some idea of the weather conditions in that area during installation. This data can be useful for future installations.

Number in complex

A complex basically describes an oilfield that has numerous platforms with different functions. As for the number in complex criteria, it requires the number of the platforms situated in that complex. This number is given by the operators of that oilfield and in this case it is Petronas Carigali Sdn Bhd (PCSB).

Linked platforms

Linked platform describes whether a platform is linked with another platform. It is usually linked by a bridge.

Sold or salvaged

"Sold or salvaged" describes a platform whether it is going to be sold or not after its design life. The engineer in charge should state YES or NO based on decisions made by the operator.

Reuse candidate

Reuse candidate is the opposite of "sold or salvaged". This is because if the platform is not sold, then it would be reused. The decision depends on the operator.

Orientation of platform

Orientation of platform describes the orientation of the platform according to wind conditions. There are 8 orientations of platforms, which are shown in table 4.4.

Table 4.4: Orientation of platform

Orientation of Platform	1. North	2. South
	3. East	4. West
	5. North-East	6. South-East
	7. North-West	8. South-West

Latitude

Latitude can be described as a measurement of location of a particular platform north or south of the equator. The lines of latitude consist of horizontal lines running from east to west on maps.

Longitude

Longitude can be described as a measurement of location of a particular platform. It is a east-west geographic coordinate measurement. A line of longitude is called a meridian and it represents half of a great circle.

4.3.2 Generic Details

A generic detail can be described as a detail that belongs to a large group of objects, which in this case a fixed offshore platform. The engineer that has been assigned to perform SIM has to get all the required data's either from the consultant, fabricators or project team to facilitate him/her. The data that is required for this Structural Integrity Management (SIM) subtopic is shown in table 4.5.

Table 4.5: Generic details of platform

Generic Details	1. Water depth	2. Jacket height	3. Air gap	4. Deck elevation
	5. Long framing	6. Tran framing	7. No of bays	8. No of legs
	9. No of piles	10. No of skirt piles	11. Grouted piles	12. Jacket weight
	13. Deck weight	14. Pile weight	15. Base length	16. Base width

Water depth

For a fixed offshore structure, the depth of water that it can be installed in is limited. The importance of knowing the water depth is to establish the elevation of boat landings, fenders, decks and corrosion protection. The maximum allowable water depth for a fixed offshore platform is currently 282 meters.

Jacket height

The jacket height of a platform has to be more then the water depth. Currently in Malaysia waters the deepest water depth for a fixed offshore platform is 282 meters.

Air gap

Air gap can be described as the air gap between the underside of the lowest part of the cellar deck and the maximum extreme storm case crest elevation. The air gap should be 1.5 meters based on Petronas Technical Specifications (PTS). If there is seabed subsidence, it should be acknowledged and additional air gap should be allowed.

Deck elevation

Deck elevation can be described as the elevation of the lowest deck which will give the allowable clearance to allow movement of wave crest. This is done to prevent the wave crest from impacting on the platform.

Number of bays

Number of bays in the platform.

Number of legs

This indicates the number of legs in the platform. For a fixed offshore structure, normally there would be 4, 6, or 8 legs.

No of skirt piles

Skirt piles can be described as additional piles connected through the sleeves at the base of the platform. The leg and piles then would anchor the platform and prevent it from overtopping due various loading conditions.

Grouted piles

State whether the platform uses grouted piles or non-grouted piles. If yes, specify the number of grouted piles used.

Jacket weight

Jacket weight would be in the range of 5,000 to 20,000 MT. The largest jacket that is currently in the world weights 35,000 MT.

Deck weight

Deck weight is between the ranges of 10000 MT to 50000 MT.

Base length

The length of the platform which is in line with platform north.

Base width

The width of the platform which is perpendicular to platform north.

4.3.3 Operational details

The operational details contain data regarding the operation of the platforms. The engineer that has been assigned to perform SIM has to get all the required data's either from the consultant, fabricators or project team to facilitate him/her. Data required in this section is listed below in table 4.6.

Table 4.6: Operational details

Operational Details	1. Manned or unmanned	2. Shore distance (Km)	3. Quarters capacity
	4. No of slots	5. No of conductors	6. No of risers
	7. No of casings	8. No of decks	9. No of cranes
	10. Maximum crane size	11. Boat landing	12. Helipad
	13. Corrosion Protection type	14. Oil production (BOPD)	15. Gas production (MCFD)
	16. Soil type		

Manned or unmanned

Manned: Platforms that is continuously occupied by workers.

Unmanned: Platforms that is not continuously occupied by workers.

Shore distance

Distance the platform is to the shore.

Quarter's capacity

If the platform has living quarters. State the capacity of the living quarters that it can accommodate.

Number of Slots

Number of drilling slots available on the platform.

Number of conductors

State the number of conductors are there on the platform.

Number of risers

Risers are the vertical portion of a subsea pipelines arriving on or departing from a platform. They link the wellhead and the drilling platform. State the no of risers are there on the platform.

Number of caisson

Caisson is the pipe extending vertically downwards from an installation into the sea as a means of disposing of waste waters, or for the location of a sea water pump. State the no of caisson are there on the platform.

Number of decks

Number of decks for the platform.

Number of cranes

Crane is materials-handling device fitted with a rotating jib. A hook suspended from the jib is used to lift and move loads. State the number of cranes on the platform.

Maximum crane size

State the maximum crane size allowed based on the platform design.

Boat landing

A boat landing is attached to the jacket after installation at an offshore location.

Helipad

Helipad is a site for the helicopters to land and take off. State whether the platform has a helipad or not.

Corrosion protection type

Should be designed in accordance with NACE RP-01-76

Oil production (BOPD)

Barrels of oils produced per day.

Gas production (MCFD

Volume of gas produced per day.

Soil type

Type of soil for the jacket foundation has to be stated. .

4.4 Yearly Inspection

The yearly inspection criteria are important to determine the inspection history of the platform. It can be divided into two main sub topics which are:

1. Inspection summary
2. Survey details

Summary of platform inspection data can be referred to Appendix 2.

4.4.1 Inspection summary

This sub topic describes the inspection summary that is carried out on the platform. The data included can be referred to table 4.7.

Table 4.7: Inspection summary

Inspection summary	1. Platform name	2. Inspection name	3. Inspection year
	4. Inspection no	5. Inspection type	6. Contractor
	7. Inspection description	8. Inspection Level	9. Other works details

From table 4.7, it is observed that the number 9 of the table refers to 'other works detail'. This 'other works detail' of the inspection program are shown in table 4.8.

Table 4.8: Other work details

Other works details	1. Weld monitoring	2. Marine growth monitoring
	3. Debris clearance	4. Anode confirmation
	5. Scour repair	6. Corrosion survey

4.4.2 Survey details

This sub topic describes the survey detail that is carried out on the platform. The data that is required for the survey details are shown in table 4.9.

Table 4.9: Survey details

Survey details	1. Video inspection	2. General visual	3. Marine growth
	4. Scour	5. Cathodic protection	6. Anodes
	7. Debris	8. Risers	9. Caisson
	10. Conductors	11. Flooded	12. Welds
	13. Wall Ultrasonic Test (UT)		

<u>Video Inspection</u>

All video inspections should be kept by the operators. This is to ensure that when future inspection is done, the operators can refer to the previous video inspection if there are any abnormalities to the platform such as cracks, dents etc.

<u>General Visual</u>

General visual can be described as normal checks done by operators or inspectors without any equipment. The required visuals that have to be acknowledged are shown in table 4.10.

Table 4.10: General visual

<table>
<tr><td rowspan="3">General Visual</td><td>1. Dents</td><td>2. Cracks</td><td>3. Abrasions</td></tr>
<tr><td>4. Bows</td><td>5. Severed</td><td>6. Holes</td></tr>
<tr><td>7. Gouges</td><td colspan="2">8. Missing members or equipment</td></tr>
</table>

<u>Marine growth</u>

The marine growth data would be available from the underwater inspection report. The 3 main data that is required is:

1. Water depth
2. Average marine growth
3. Allowable marine growth based on design specifications

<u>Scour</u>

Scour is the removal of the seabed in the vicinity of the jacket by tidal action. In the Structural Integrity Management (SIM) procedure, the scour data has to be kept by the operators. Scour can be divided into two parts which are:

1. Local scour
2. Global Scour

In both of these parts, the data that is needed are:

1. The scour depth
2. Allowable scour depth by design

<u>Cathodic protection</u>

Cathodic protection is used to prevent corrosion on jacket members. Petronas Carigali Sdn Bhd (PCSB) operated platforms currently uses sacrificial anodes to protect its jackets. The data that is required for cathodic protection are:

1. Allowable values (Max, Average, Min)
2. Potential values (Max, Average, Min)

Anodes

The data is required for platform anodes is the anode grade and no of anodes are there on the platform.

Debris

Any debris that is on the platform or in the surrounding areas has to be stated.

Risers

Any abnormalities on the riser have to be stated for instance crack, dent or paint removal.

Caisson

Any abnormalities on the caisson have to be stated for instance crack, dent or paint removal. Besides that the number of casings has to be stated also.

Conductors

Any abnormalities on the conductors have to be stated for instance crack, dent or paint removal. Besides that the number of casings has to be stated also.

Flooded

Flooded members have to be tested and the results have to be stated. The data that is required for flooded members are:

1. Number of test done.
2. Number of full flooded test done.
3. Number of partial flooded test done.
4. What members the test was conducted on.

If a member is flooded, it shows that it is leaking and the welding was not done properly. Furthermore if the flooded members fail because of anomalies or a hole in it, it can affect the strength of the member and subsequently effect the structural integrity of the platform.

Welds

Weld checks are important to make sure there are no leaks and cracks on the welded members. Furthermore weld data from the fabrication yard is important to make sure all the welders follow strict guidelines and codes that are approved by Petronas Carigali Sdn Bhd.

Wall Ultrasonic Test (UT)

Wall ultrasonic test is done to check for leaks on tubular joints. The test results have to be kept for future reference and part of Structural Integrity Management (SIM) process.

4.5 Assessment

A platform fitness-for-purpose assessment is a detailed evaluation or structural analysis that has to be carried out because it determines the platform strength against the acceptance criteria obtained from the design codes. This assessment can be divided into 4 subtopics which are:

1. Analysis details.
2. Analysis information.
3. Analysis Data.
4. Platform risk matrix

Each of these is explained below. Summary of platform analysis data (Refer: Appendix 3).

4.5.1 Analysis Details

The data that is required for "analysis details" is shown in table 4.11.

Table 4.11: Analysis Details

Analysis Details	1. Platform Name	2. Analysis ID	3. Analysis Year
	4. Analysis Type	5. Analysis Software	6. Analyst
	7. Analysis Description		

4.5.2 Analysis Information

This is the data necessary for the assessment. The data should mostly be available from existing platform characteristic data and inspection data. The data should be up-to-date and reflect the condition of the platform at the time of the assessment. The data that are required is shown in table 4.12.

Table 4.12: Analysis Information

Analysis Information	1. Drawings	2. Weight database	3. New Metocean criteria	4. Pile data
	5. SACS model	6. Full assessment results	7. Summary of assessment results	

4.5.3 Analysis Data

Analysis data is the data that is required for an analysis/assessment to be carried out. The data should be up-to-date and reflect the condition of the platform at the time of the assessment. The data that are required is shown in table 4.13.

Table 4.13: Analysis Data

Analysis Data	1. Caisson	2. Conductors	3. Tide
	4. Maximum wave height	5. Deck Elevation	6. Deck Load
	7. Marine growth	8. Scour	9. Conductor subsidence
	10. Corrosion	11. Damage quantity	12. Crack Quantity

4.5.4 Platform Risk Matrix

The result of this assessment would then be input into the risk matrix. The risk matrix will be explained more in the evaluation section. (Section 4.9).

4.6 Data Management

Data management is crucial in ensuring the effective implementation of this SIM process. This is because with less data, assumptions have to be made in ensuring the fitness for purpose of an offshore platform. Therefore one of the vital and simple data management systems that can be used by an operator is the Data document Index (Refer: Appendix 4). This data document index would include data such as platform name, field, risk ranking and all the data that is available to the platform.

4.7 Malaysia platform age frequency

Besides the Structural Integrity Management (SIM) outline, the author also has managed to gather some information about Petronas Carigali Sdn Bhd (PCSB) operated platforms. There are currently 175 platforms operated by PCSB in 3 different regions. These 3 regions are Peninsular Malaysia Operations (PMO), Sabah Operations (SBO) and Sarawak Operation (SKO).

Figure 4.1 shows the number of platforms in Malaysian water that has exceeded its design life of 25 years. There are 90 platforms in Malaysian waters that have exceeded its design life of 25 years. The section that is highlighted shows the number of platform that has exceeded its design life of 25 years.

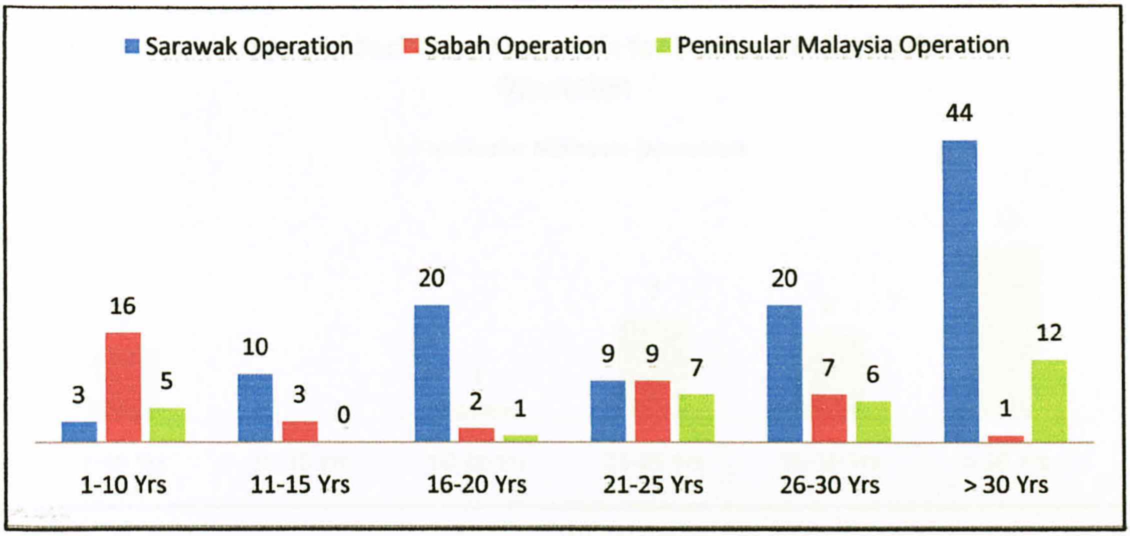

Figure 4.1: Number of platforms vs. Age frequency

Figure 4.2, 4.3 and 4.4 shows the distribution of the ages of platforms for Peninsular Malaysia Operations (PMO), Sabah Operations (SBO) and Sarawak Operations (SKO) respectively.

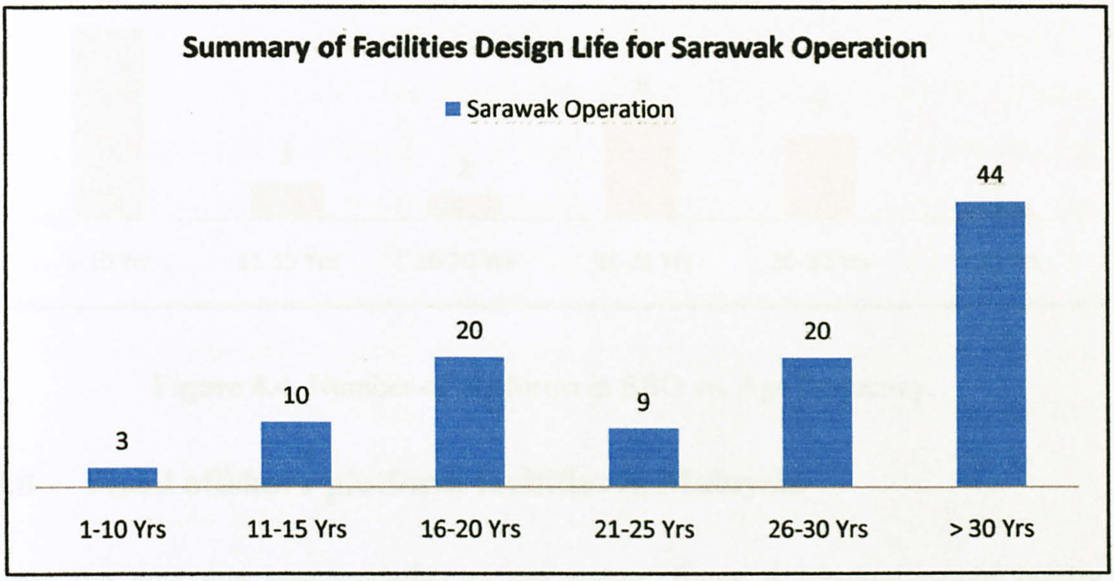

Figure 4.2: Number of platforms in SKO vs. Age frequency.

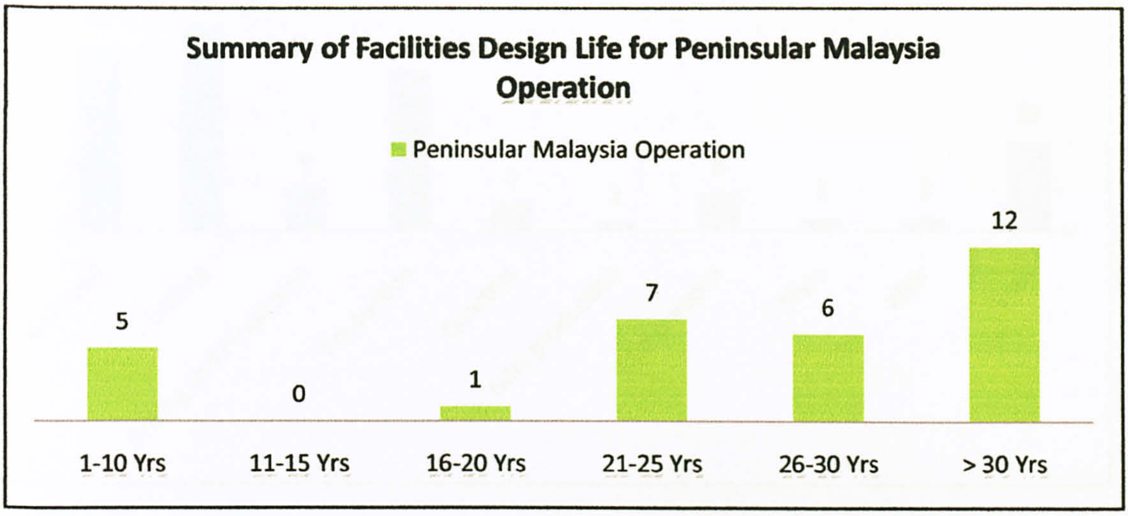

Figure 4.3: Number of platform in PMO vs. Age frequency.

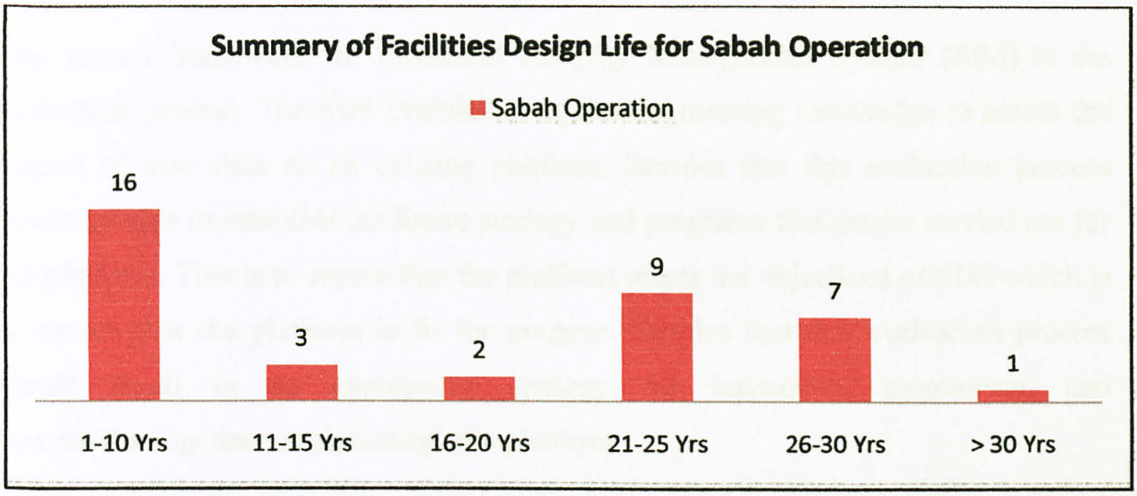

Figure 4.4: Number of platforms in SBO vs. Age frequency.

4.8 Fixed offshore platform facilities in Malaysia

From the data that was available to the author, figure 4.5 below would briefly illustrate the types of platform that is operated by PETRONAS in Malaysia. The types of platforms range from drilling, wellhead, production, gas compression, living quarter, vent and riser. As can be seen, drilling platforms constitute about 26% off the overall platform category in the country. The lowest number of platforms belongs to the category of "mini production facility" with only 1.2% out of the total platforms.

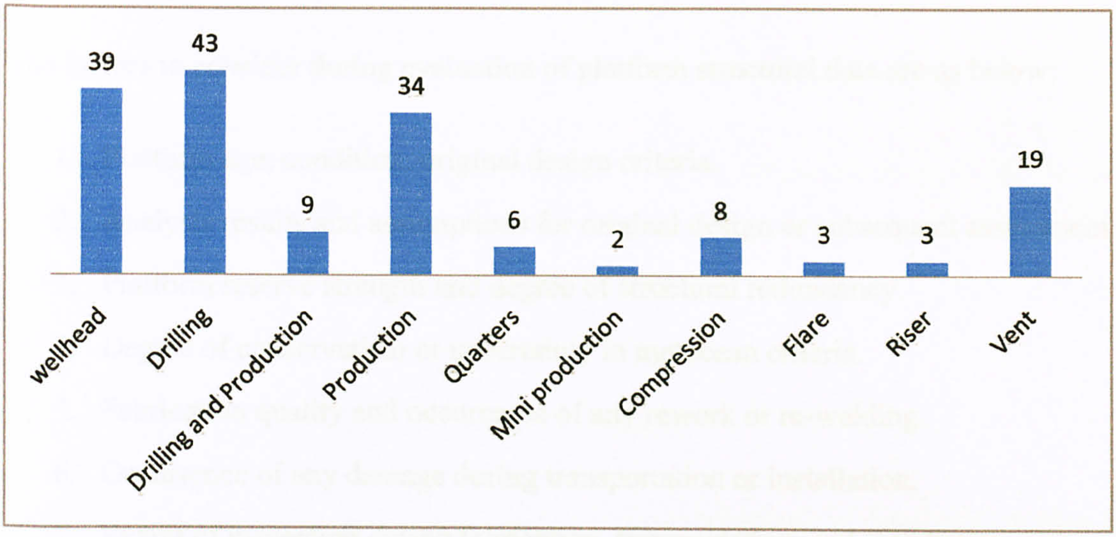

Figure 4.5: Different types of offshore platforms in Malaysia

4.9 Data Evaluation

The second framework for Structural Integrity Management System (SIM) is the evaluation process. The SIM evaluation applies engineering knowledge to assess the impact of new data on an existing platform. Besides that this evaluation process would be able to establish the future strategy and programs that can be carried out for the platform. This is to ensure that the platform meets the objectives of SIM which is to ensure that the platform is fit for purpose. Besides that this evaluation process would result in an appropriate strategy for inspection, monitoring, and commissioning/ decommissioning of a platform.

This evaluation process is carried out throughout the life span of a platform. As long as there is new data that is being received by the operator, evaluation of the data has to be carried out using engineering knowledge to identify any problems on the platform and take appropriate actions to rectify it. This evaluation process is not an engineering analysis process for example structural analysis. It is merely an evaluation of data of a platform and mostly engineering judgments based on specialist knowledge or operational experience, simplified analysis, or reference to research data, detailed analysis of similar platforms or similar works that has been carried out by other operators in that specific region.

The factors to consider during evaluation of platform structural data are as below:

1. Platform age, condition, original design criteria.
2. Analysis results and assumptions for original design or subsequent assessment.
3. Platform reserve strength and degree of structural redundancy.
4. Degree of conservatism or uncertainty in metocean criteria.
5. Fabrication quality and occurrence of any rework or re-welding.
6. Occurrence of any damage during transportation or installation.
7. Extent of inspection during fabrication, transportation, and installation.
8. Previous inspection findings.
9. Learning from structural performance of other platforms.
10. Platform modifications, additions, and repairs/strengthening.
11. Accidental (i.e., fire, blast, vessel impact, dropped object, etc.) or metocean or other design event overload.
12. Past performance of corrosion protection system.
13. Criticality of platform to other operations.
14. Platform location (frontier area, water depth).
15. Platform monitoring data if available.

Sometimes for operators, the availability of data is a problem. Most contractors do not have adequate data of their platform. It has to be remembered that inadequate data would impact the evaluation process because no data means no evaluation and this would result in a problem for operators. Without evaluation no strategy and programs can be develop for the platform. Overall the SIM process would be affected.

It is advised that if an operator does not have data such as the platform characteristics, surveys of the specified platform can be carried out to obtain the data and further visual inspections can be done to detect any anomalities at the platform.

4.9.1 Risk Categorization of a fixed offshore platform

Petronas Carigali Sdn Bhd. (PCSB) categorizes its platform based on a risk based inspection (RBI) tool. This SIM process is associated with the RBI tool because the higher the risk the platform possesses, the higher the need for a SIM process to be carried out on the platform. Risk can be defined as:

Risk = Consequence of failure x Likelihood of failure

After a risk value has been assigned to a platform, a risk matrix is developed to give a clearer picture of the risk of the platform for people to be able to understand. PCSB does this by using a risk matrix. There are two types of risk matrix, 1 is the 3 by 3 matrix and the other is a 5 by 5 matrix. PCSB uses the 5 by 5 matrix to categorize their platforms.

4.9.2 Risk Matrix

A risk matrix is developed based on defined parameters. Those two parameters are Likelihood of failure and Consequence of failure. These parameters are scored and have different weighted factors. An example risk matrix is shown in table 4.4.

Table 4.14: Risk Categorization Matrix Example

Likelihood of Failure	5	M	H	H	VH	VH
	4	L	M	H	H	VH
	3	L	L	M	H	H
	2	VL	L	L	M	H
	1	VL	VL	L	L	M
		A	B	C	D	E
	Consequence of failure					

VH	Very high
H	High
M	Medium
L	Low
VL	Very Low

In this table the consequence and likelihood categories are arranged such that the highest risk ranking is toward the upper right-hand corner. The lowest risk items fall into category A1 and the highest risk items fall into category E5. This can be seen from the table above.

4.9.3 Likelihood of failure

- **Factors affecting likelihood of failure**

The likelihood of structural collapse of a platform can be subjected to two factors namely:

1. Platform strength or capacity.
2. Extreme loading the platform is exposed to.

The likelihood of failure categorization system identifies the characteristics of platforms that affects its structural strength and loads. The likelihood of failure of a platform would increase if there is an indication that there are factors attributing to the deterioration of platform strength or not up to current design practice. Besides that, if there are factors indicating that extreme platform loads may increase in frequency or severity, the likelihood of failure of the platform would also increase.

In the risk ranking, an assumption is made that all jacket type platforms designed according to latest structural design practice to resist present day design environmental loads have the lowest likelihood of failure. The factors that affect the original strength, the maximum design loads, and the degradation of strength are used to measure any individual platform's failure likelihood against an ideal platform. Below are the factors affecting the degradation of strength of a platform and exposure to risk scenarios.

Risers, conductors and caisson support

- Because of the risk of fire or a toxic release, the failure of a riser or conductor can escalate to a total loss failure.

Results from inspection reports, such as:

- Anode grading or monitoring of the corrosion protection systems.
- Detected damage members and cracks.
- Flooded member surveys.
- Member thickness measurements.

All of those reports above are related to the assessment of the current condition of the platform. The corrosion protection system has to undergo frequent maintenance and inspection because it contributes to the degradation of the structure. If a structure is corroded, its structural members have less strength and can fail easily.

Damage and flooded members indicate that overall strength and ductility may be reduced if during the inspection it is found that the system has a degree of failure. Besides that, observed corrosion may indicate that the corrosion protection and coating are no longer operating effectively.

Fitness for purpose

- This is the main objective of SIM. To ensure that a platform is fit for its purpose and can continue doing so after exceeding its design life.

Year installed

- Over the years, the design loads used for the platform may change. The metocean criteria have to be studied in order to identify whether they have changed from the initial design values.

Number of legs

- Eight and six leg platforms are more redundant than three and four leg platforms. The number of legs together with the bracing system is a strong indicator of the overall redundancy and damage tolerance of a platform.

Recent inspection history

- Inspection would be carried out on a platform periodically based on the risk of the platform and also the cost. While there would be many inspection results throughout the years, the recent inspection history would be able to describe the current condition of the platform.

Marine growth

- Excess marine growth may not decrease the strength of a member, but because marine growth increases the surface area of a member, it would result in the increase of drag force. If the amount on growth exceeds that assumed for the design, the loading on the structure would also increase.

Change of service

- There are various services for an offshore platform. It varies from production to drilling platforms and the amount of load the platform can accommodate also varies. For example, drilling platforms must support the weight of drilling equipment and drilling operation loads. If the platform service is switched to production, the drilling equipment is removed, the platform loads change.

Deck elevation

- Wave in deck increases the loading significantly. If a deck has low elevation, the likelihood that it would be hit by a wave is higher and might be a primary cause of platform failure.

Scour depth

- Excess scouring would expose more piles to hydrodynamic loads and this would result in the reduction of foundation support. Therefore would increase the likelihood of failure.

- **High Likelihood of failure**

The high likelihood of failure category refers to existing platforms that are likely to fail in the design event. Platforms in this category are non-robust, may have cellar decks that could be inundated during the event and/or have little tolerance to damage.

- **Medium Likelihood of failure**

The medium likelihood of failure category refers to existing platforms that are not expected to fail during the design event. However, these structures may sustain damage that requires inspection after the design event. These are essentially platforms that do not meet the high likelihood or low likelihood definitions.

- **Low Likelihood of failure**

The low likelihood of failure category refers to existing platforms that are unlikely to fail during the design event. This implies sufficient reserve strength for the platform's present condition, including all modifications and known damage, against the 100-year design that the platform would remain undamaged during the design event. Platforms in this category are robust and tolerant to damage.

4.9.4 Consequence of Failure

- **General**

The consequence of failure has three main components. They are:

1. Environmental loss
2. Business loss
3. Injuries and safety related loss

These components are calculated based on monetary losses to the operator. This three component monetary losses is summed up to come out with the overall result consequence.

While the resulting dollar value obtained does not represent the total amount of money that could be lost to a failure, this concept is adopted to combine the effect of safety, environmental and business losses.

The value of hurricane damage, injury, and business losses can be estimated using these criteria below. These criteria are based on relations between:

1. Platform size
2. Crew size
3. production rate
4. And the consequences if one of this components fail

While each type of consequence is measured in a common unit (monetary losses), different factors determine the value of each type of loss. When possible, these consequence calculations are quantitative and are related to the actual economic values such as the price of oil and gas and the cost of development of an offshore oil and gas field.

- **Environmental loss**

This is the volume of oil or other hydrocarbons released to the sea. The cost of cleaning up, fees and fines that would result in the spill is taken into consideration.

- **Business loss**

This is the total value of the reserve, the expected rate of return on investment, the expected number of months that the platform would not produce, the cost of repairing or replacing a damaged or a lost platform due to a collapse.

- **Safety loss**

This is the average number of crew on the platform, whether it is continuously manned, the type of production and the loss of crew members due to unforeseen circumstances.

- **High Consequence**

The high consequence of failure category refers to existing platforms that have the potential for well flow or sour gas in the event of platform failure. If a well flow or sour gas occurs, the environment would be polluted and a high cleanup cost has to be fork out by the operator. Besides that, these platforms support major oil pipelines and also offer storage capacity. All platforms in water depths greater than 400 ft. are also considered high consequence.

- **Medium Consequence**

The medium consequence of failure category refers to existing platforms where production would be shut-in during design events such as hurricane and high wave's conditions. The wells would contain subsurface safety valves that can be shut down in case of emergency and oil storage would be limited to process inventory. Besides that these platforms must have surge tanks for pipelines. These surge tanks are required to pump and store oil when during an emergency occurs from the pipeline. These are essentially platforms that do not meet the high consequence or low consequence definitions.

- **Low Consequence**

The low consequence of failure refers to existing platforms where production will be shut-in during design events, the wells contain subsurface safety valves and oil storage is limited. These platforms may support production departing from the platform and low volume infield pipelines.

It is possible that some older, larger platforms with more wells, more production equipment and in deeper water that is nearing the end of their useful life have a similar consequence of failure and can be considered low consequence.

4.10 STRATEGY

The third framework for Structural Integrity Management System (SIM) is the strategy process. The SIM strategy is applied when the appropriate technical experts have come out with the evaluation results. The SIM strategy would then come out with a detail description that answers these following questions:

- What type of inspection should be done
- What is the benefits of inspection strategy
- What are the requirements inspection strategy
- How the inspection should be done

These strategies that would be carried out will ensure that the platform meets the objectives of SIM which is to ensure that the platform is fit for purpose. Furthermore, it would give specific recommendations for 1) Inspection strategy and 2) Mitigation and risk reduction options.

4.10.1 Inspection Strategy

The structural inspection strategy would be developed based on the evaluation process that had been carried out earlier. These inspection strategies should be developed as soon as a platform has been commissioned.

This is because when an operator has an inspection strategy of their platform, they can pre-plan all the other management aspects of inspection which is the cost, time, and appropriate contractors to do the inspection on a specific platform.

But sometimes due to unforeseen circumstances like boat accidents, earthquake and tsunamis, these inspection strategy can be revised and updated periodically based on the platform performance.

- **Inspection types**

Petronas Carigali Sdn Bhd (PCSB) conducts the inspection of their platform based on American Petroleum Institute (API) recommended practices and guidelines. In this study we would see what types of inspection can be carried out on PCSB platforms and the benefits of it.

- **Scheduled Inspection**

a) Baseline

Baseline inspection is the first inspection carried out to determine the initial condition of a structure and to use it as a benchmark for future inspections. This baseline inspection is done to:

1. Determine initial condition of equipment that is not inspected in fabrication or installation inspection.
2. To check any damage that occurred on the structure during transportation and installation.

b) Periodic

Periodic inspection is carried out to determine the structural integrity of a structure at a certain period during its life cycle. It inspects for example the cathodic protection and also any anomalities that occur on the platform.

The main aspect of periodic inspection is the interval and scope of work. The interval depends on the evaluation result of the platform data's and if the platform is found to be unsafe or very high risk, the frequency of interval would be shorter. This means frequent inspection in a short space of time.

c) Special

Special inspection contains key elements such as the objectives of inspection, selection of tools and techniques, scope of work and intervals. It is more like the periodic inspection that is carried out on a platform but the major difference is that special inspection conducts repairs, remediation program, known damage and defects, whereas periodic inspection inspects for example the cathodic protection and also any anomalities that occur on the platform.

d) Emergency

Emergency inspection is carried out when there is an incident at the platform. This type of inspection is unscheduled and not planned. Emergency inspection is carried out on a platform due to:

1. Extreme wave conditions that affects the structural integrity of the platform
2. Accident at the platform for example boat accident and many more

4.10.2 Mitigation and Risk Reduction

Mitigation is defined as modifications or operational procedures that reduce the consequence exposure of the structure such as de-manning a platform, and the reduction of oil storage or in order to reduce the consequence of platform failure.

Risk reduction is defined as modifications that reduce the likelihood of structural failure and includes such measures load reduction or an increase in system strength through global or local strengthening and repairing.

4.10.3 Benefits of having an inspection strategy

1. Reduce inspection cost by strategizing inspection to accommodate a number of platforms at the same location on the same time.
2. The scope of work for the platform inspection can be done in advance and submitted to the consultant. This could reduce time.
3. The inspection interval can be designed based on the evaluation of the platform. By having an inspection strategy, the platform need not be inspected often and therefore it can reduce the operator's operating expenses.
4. By having an inspection strategy, the integrity of the platform can be preserved because it would undergo periodic evaluation to check whether it meets its fitness for purpose.

4.11 PROGRAM

The Program represents the execution of the detailed scope of work and should be conducted to complete the activities defined in the SIM strategy. The Program may include one or more of the following:

- **Routine above water inspections**: An above water inspection should be carried out on an annual basis.
- **Baseline underwater inspection**: The baseline underwater inspection should be carried out to determine the as-installed platform condition, and as a benchmark for the future SIM of the platform. A baseline inspection should be conducted prior to implementation of risk-based inspection.
- **Routine underwater inspections**: The routine underwater inspection should be carried out to provide the information necessary to evaluate the condition of the platform and should be carried out at an interval consistent with the SIM strategy adopted by the operator.
- **Special inspections**: A non-routine inspection initiated by events such as a hurricane or collision.

The Program represents the execution of the detailed scope of work and should be conducted to complete the activities defined in the SIM strategy. The Program may include one or more of the following activities; routine above water inspections, baseline inspections, routine underwater inspections, special inspections and Strengthening, Modification and/or Repair (SMR) activities.

To complete the SIM process all data collected during the SIM Program should be incorporated back into the SIM data management framework. Consistency, accuracy and completeness of inspection records are important since these data form an integral part of the SIM framework.

4.12 CASE STUDY

4.12.1 Introduction

This case study is being carried out on SMG-A platform which is located in the Semarang Field offshore Sabah. SMG-A is a six leg fixed Gas Compression Platform and is still active. SMG-A was installed on 1/1/1983 and currently has exceeded its design life of 25 years. Therefore an effective SIM process is needed to ensure that SMG-A is still fit for purpose.

4.12.2 Data

a) Generic Details of SMG-A

SMG-A is installed in water depth of 10.1 m. Its jacket height is 10.4 m. The air gap is 5.0 m which is above the recommended value by PTS. PTS specify that the minimum value of air gap should be 1.5 m above sea level for all its platforms. The deck elevation for SMG-A is 12.2 m. SMG-A also uses K-framing for both its longitudinal and transverse frames. The deck weight of SMG-A is 1361 MT. Its base length is 33.5 m and base width 18.3 m. See Table 4.15.

Table 4.15: Generic Details of SMG-A

Generic Details	
Water depth	10.1 m
Jacket Height	10.4 m
Air Gap	5.0 m
Deck Elevation	12.2 m
Long framing	K
Tran framing	K
# of bays	2
# of legs	6
# of piles	6
# of leg piles	6
# of skirt piles	0
Grouted Piles	No
Jacket weight	NA
Deck weight	1361 MT
Pile weight	NA
Base length	33.5 m
Base width	18.3 m

b) Operational Details of SMG-A

SMG-A is an unmanned platform. Although it is unmanned, it also has a quarter's capacity of 3 people. This quarter is accommodated for inspection and maintenance staffs. SMG-A has 3 caissons, 0 conductors and 7 riser guards. SMG-A has 1 crane on its platform and 1 boat landing. SMG-A does not have a helipad. Its corrosion protection is the sacrificial anodes. See table 4.16.

Table 4.16: Operational Details of SMG-A

Operational details	
Manned	Yes
Shore distance	NA
Quarters capacity	3
# of slots	NA
# of caisson	3
# of conductors	0
# of Risers	7
Max cond. Dia.	NA
# of decks	NA
# of cranes	1
Max crane size	NA
Boat landing	Yes
Helipad	No
CP type	SA
Oil Prod	NA
Gas Prod	NA

c) Platform Inspection Data of SMG-A

Figure 4.6: Row 3 (A1-B3) Platform North

Figure 4.7: Row 1 (A1-B1) Platform South

From its commissioning in 1/1/1983, SMG-A has undergone 2 underwater inspections (UI). 1 was done in 1994 and another in 2005. The data for UI in 1994 is not available. This UI report in 1994 is essential because it can be considered as a baseline UI. The more favorable condition would be that an UI should have been carried out in 1983.

This is because baseline underwater inspections should be considered to determine the as-installed platform condition to benchmark for the future SIM of the platform, especially if any potential damage occurred during installation. A baseline inspection should be conducted before the implementation of risk-based inspection (RBI) planning for the platform.

The minimum scope of work should consist of the following, unless the information is available from the design and installation records:

- A visual survey of the platform for structural damage, from the mud line to top of jacket.
- A visual survey to verify the presence and integrity of the anodes.
- A visual survey to confirm of the number of installed appurtenances and their integrity.
- Confirmation of the as-installed platform orientation.
- Measurement of the as-installed platform level.

As for the UI in 2005, the scope of work (SOW) that was carried out is explained below.

d) Inspection Level

The inspection level for UI 2005 is API Level 2. A Level 2 survey consists of general underwater visual inspection. It is done to detect the presence of any or all of the following:

1. Excessive corrosion.
2. Scour and seafloor instability, etc.
3. Design or construction deficiencies.
4. Presence of debris.
5. Excessive marine growth.

Detection of significant structural damage during a Level 2 survey should become the basis for initiation of a Level 3 survey. The Level 3 survey, if required, should be conducted as soon as conditions permit.

e) General Visual Inspection

Forty three (43) members comprised the jacket structure. Six (6) members were inspected and no damage, deformation or other anomaly was found.

f) Splashzone Inspection

A total of twenty (20) members of the jacket pass through the air and water interface. These members consisted of the six (6) jacket legs and fourteen (14) vertical diagonal members (VDM). Inspection was completed on two (2) jacket legs and five (5) vertical diagonal members. No areas of coating breakdown were observed on the members that were inspected. No anomalies were reported during this inspection.

g) Base level Survey

The gap between the underside of the bottom level horizontal members and the seabed was estimated using divers. Scour measurements at the base level are the vertical separation between each horizontal members and the seabed. This distance was estimated at both ends and at the centre of each Face; which was at A3-B3 Face. The measurements for Face A3-A2-A1 were taken at leg A3 and A2. Measurements for the other two (2) faces were not taken. No exposed pile was observed during the inspection

h) Anode inspection

A total of twenty seven (27) anodes were found on the Jacket Structure. Only four (4) anodes were inspected and the depletion rate range between 20%-60%. No anomalies were reported for this inspection.

i) Cathodic Potential Survey

Thirty Nine (39) contact Cathodic Potential measurements were obtained on jacket nodes, risers and riser clamps. Air divers were utilized to obtain the contact CP measurements. The measurements ranged between (-)659mV to (-)1068mV.

j) Marine Growth Inspection

A marine growth (MG) survey was carried out by air divers on Leg A3 and B3. Circumferential measurements were obtained from MSL to EL (-)10m in 5 meters increments. At Leg A3, the marine growth was most dense at EL (-)5m down to EL (-) 10m; measured as 84.36mm thick. Whereas at Leg B3, the marine growth was most dense at EL (-)10m; measured as 100.38mm thick. The Marine Growth consisted of Barnacles, Clams, Sponges, Hydroids, soft and hard corals.

k) Seabed Debris

Twelve (12) items of debris were noted during the seabed debris survey. The twelve (12) items were mostly metallic debris consisting of cut-off pipe section, scaffolding poles and grating.

l) Anomaly Summary

The following anomalies were found during the course of the project:

1. Low CP measurements of (-)659mV and (-)660mV were reported on Riser no. 7.
2. One boat landing was located at Row 3. Missing gratings were observed at lower stage boat landing, and at the top 3 grating steps of the stairway between the two stages of the boat landing.

4.12.3 Evaluation

a) Platform Risk Ranking

Petronas Carigali Sdn Bhd. (PCSB) categorizes its platform based on a Platform risk ranking tool. This SIM process is associated with the RBI tool because the higher the risk the platform possesses, the higher the need for a SIM process to be carried out on the platform. Risk can be defined as:

Risk = Consequence of failure x Likelihood of failure

After a risk value has been assigned to a platform, a risk matrix is developed to give a clearer picture of the risk of the platform for people to be able to understand. PCSB does this by using a risk matrix. PCSB uses the 5 by 5 matrix to categorize their platforms.

A risk matrix is developed based on defined parameters. Those two parameters are Likelihood of failure and Consequence of failure. These parameters are scored and have different weighted factors. For SMG-A, after obtaining all the result from the UI done in 2005, the scores are as below:

1. Likelihood Score : 320
2. Consequence Value : 32.34
3. RSR : 3.24
4. Likelihood of Failure : 3
5. Consequence of Failure : B
6. Platform Risk : Low (3B)

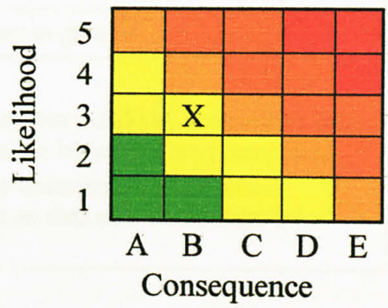

Figure 4.8: SMG-A Risk Category (Low)

4.12.4 Strategy

The third framework for Structural Integrity Management System (SIM) is the strategy process. The SIM strategy is applied when the appropriate technical experts have come out with the evaluation results. The SIM strategy would then come out with a detail description that answers these following questions:

- What type of inspection should be done
- What is the benefits of inspection strategy
- What are the requirements inspection strategy
- How the inspection should be done

These strategies that would be carried out will ensure that the platform meets the objectives of SIM which is to ensure that the platform is fit for purpose.

For SMG-A, the next inspection that should be done is a Risk Based Level 3 UI. The Risk Based UI should be done in year 2015. This is because according to API recommended practices and guidelines, since SMG-A is a low risk platform; the appropriate inspection interval is 11 years or greater. See table 4.17.

Table 4.17: Risk Based Inspection Program (API RP2A, Section 17)

Risk Category	Inspection Interval Ranges
High	3-years to 5-years
Medium	6-years to 10-years
Low	11-years or greater

Notes:

a) The timing for the first underwater periodic inspection should be determined from the date of platform installation or when the baseline inspection was completed.

b) Risk-based intervals should be adjusted to ensure uninterrupted cathodic protection of the platform. This should be based on data evaluation from prior inspections.

Not only undertaking a risk based approach to come up with a SIM strategy, there is another method to be used which is the consequence based inspection program. These program states that the consequence-based inspection program provides a predefined in-service inspection program should Owner/Operator choose not to implement SIM. Consequence based inspection program states that for Level 3 inspection, concerning low risk platforms, the interval is also more than 10 years. See table 4.18.

Table 4.18: Consequence Based Inspection Program (API RP2A, Section 17)

	Consequence Categorization		
	Low A-3/L-3	**Medium A-2/L-2**	**High A-1/L-1**
Interval (Years)		**10**	**6**
Level III			
Visual Corrosion Survey	X[3]	X[3]	X
Flooded Member Detection		X	X
Weld/Joint Close Visual		X	X

Therefore, the most appropriate time to do a Level 3 UI for SMG-A would be in year 2015. A Level 3 survey consists of an underwater visual inspection of preselected areas and, based on results of the Level 2 survey, areas of known or suspected damage. Such areas should be sufficiently cleaned of marine growth to permit thorough inspection.

Detection of significant structural damage during a Level 3 survey should become the basis for initiation of a Level 4 survey where visual inspection alone cannot determine the extent of damage. The Level 4 survey, if required, should be conducted as soon as conditions permit.

4.12.5 Program

As we know, SMG-A has missed its baseline inspection, the only reference data that is available is the UI in 1994 and 2005. The proposed inspection to be carried is the level 3 survey and UI in year 2015. This is because according to API recommended practices and guidelines, since SMG-A is a low risk platform; the appropriate inspection interval is 11 years or greater.

A Level 3 survey consists of an underwater visual inspection of preselected areas and/or, based on results of the Level II survey, areas of known or suspected damage.

Such areas should be sufficiently cleaned of marine growth to permit thorough inspection. Pre-selection of areas to be surveyed should be based on an engineering evaluation of areas particularly susceptible to structural damage, or to areas where repeated inspections are desirable in order to monitor their integrity over time.

Detection of significant structural damage during a Level 3 survey should become the basis for initiation of a Level 4 survey in those instances where visual inspection alone cannot determine the extent of damage. The Level IV survey, if required, should be conducted as soon as conditions permit.

CHAPTER 5:

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

In this work, issues related to Structural Integrity Management (SIM) of fixed offshore platform are studied. These include a review of existing standards applicable for SIM namely ISO 19902-2004 Section 23 and 24 and API RP 2A Section 17: Assessment of Existing Platforms. However, elements of these standards were further investigated in this thesis to produce a recommended practice for SIM in Malaysia. This includes obtaining data on Malaysia's fixed offshore platforms such as types of facilities, age, location and also risk associated with each platform.

A comprehensive review was also done to determine the recent hurricane disasters and their impact on SIM. During Hurricane Ivan, Rita and Katrina, a total of 118 platforms were destroyed. This showed that although API improves their codes every time after a disaster occurs; it still could not prevent the impact of these hurricanes to the structure.

A case study was also conducted on Semarang-A (SMG-A) platform. SMG-A is a 26 year old platform in Sabah Operation (SBO). During the study, it was discovered that there was a gap in SMG-A inspection program. Prior to that, during the data gathering process, it was clear that most of the data was missing and scattered. Besides that, SMG-A did not undergo a baseline underwater inspection prior to its installation in 1983.

A baseline underwater inspection is needed to determine the as-installed platform condition which will serve as the benchmark for the future SIM of the platform, especially if any potential damage occurred during installation. Because of this, any damage that occurred during the installation of SMG-A was not known to the operator until the first underwater inspection that was carried out in 1994.

Studies on SIM of fixed offshore platform for Malaysian waters would be a help to all the oil and gas operators in the country. SIM is an ongoing life cycle process for ensuring the continued fitness-for-purpose of offshore fixed platforms. The SIM process has evolved over the years to provide industry and regulatory bodies a means to ensure the continued safe and reliable operation of the aging fleet of offshore platforms around the world.

5.2 Recommendations and Future Works

To improve the SIM strategy in Malaysia, based on the author's experience, there is a need for an efficient way of handling data of each platform that PCSB operates. It can be done by having a document index that monitors the movement of data in the organization.

Besides that, having a standalone Petronas Technical Specification (PTS) - SIM would greatly enhance the capabilities of PCSB in managing its offshore structures. This is because Structural Integrity Management is vital life-cycle process used for the continued safe operation of existing offshore platforms and provides a framework for the assuring the fitness-for-purpose of these structures.

Throughout the life of the facility new data is collected e.g. through periodic inspections, as a result of accidental events or from planned modifications or additions to the platform. Data may also emanate from technology development projects or service experience of similar structures within industry.

This data is subject to qualified engineering evaluation to assess what impact it has on the existing SIM strategy for the facility. If necessary the inspection Program is adjusted in accordance with the change in strategy, this might mean, for example, that the inspection becomes more detailed perhaps moving from visual to Non Destructive Testing (NDT) survey techniques or vice versa.

By having a standalone Petronas Technical Specification (PTS) – SIM, operator can avoid the case of SMG-A, where a baseline inspection was missed and it could provide operators with a more organized way to manage their platform data. As a result, the SIM process can be carried out effectively and the platform life can be extended beyond its design life of 25 years.

The author would also like to propose some future works that can be carried out with respect to SIM. Since the author has carried out a case study on a platform in Malaysia and found some gaps, it is proposed that more case studies are carried out on Malaysia's fixed offshore platforms to identify gaps in their inspection and data management so that actions can be taken to close these gaps.

Besides that, this SIM process can also be used for pipelines. This is because pipelines are also a main component in the production of oil and gas. Therefore it is very important to have pipelines that are fit for purpose. Besides that, by having a SIM for pipelines, the pipelines can be used beyond its designed life because it is maintained properly and inspections are done systematically based on the evaluation of the pipelines.

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APPENDICES

APPENDICES

Appendices 1: Platform Characteristic Data

Platform Details			
Platform			
Field name			
Platform type			
Platform function			
Heritage			
Operational Status		Holding	
Installation method		Installed	
# in complex			
Linked platfoms			
Sold or Salvaged			
Re-used candidate			
Platform re-used			
Orientation			

Latitude	°		"
Longitude	°		"

Description

Remarks

Last update	

Generic Details	
Water depth	m
Jacket Height	m
Air Gap	m
Deck Elevation	m
Long framing	
Tran framing	
# of bays	
# of legs	
# of piles	
# of leg piles	
# of skirt piles	
Grouted Piles	
Jacket weight	
Deck weight	
Pile weight	
Base length	
Base width	

Soil type	
SZ protection	

Operational details	
Manned	km
Shore distance	
Quarters capacity	
# of slots	
# of conductors	
# of Risers	
# of Casings	
Max cond. Dia.	cm
# of decks	
# of cranes	
Max crane size	
Boatlanding	
Helipad	
CP type	
Oil Prod	BOPD
Gas Prod	MCFD

Appendices 2: Platform Inspection Data

Inspection summary	
Platform Name	
Inspection Name	
Inspection Year	
Inspection No	
Inspection Type	
Contractor	

Inspection Description

Inspection Level		Other Work Details	
API Level 1		Weld Monitoring	
API Level 2		Marine growth Cleaning	
API Level 3		Debris Clearance	
API Level 4		Anode confirmation	
Special		Scour repair	
		Corrosion Survey	
		Other	

Survey details								
Damage	Dents		Bows		Gouges			
	Cracks		Severed		Missing			
	Abrasion		Holes		Other			
Marine Growth	Depth (ft)	0-40		40-80		80-120	>120	
	Average	in		in		in	in	
	Allowable	in		in		in	in	
Scour		Local		Global				
	Depth (ft)	ft-in		ft-in				
	Allowable	ft-in		ft-in				
Cathodic	Value	Max		Avg		Min		
	Potential							
Anodes	Grade	1	2	3	4	Total		
	Anodes							
Debris								
Risers								
Caisson								
Conductors								
Flooded		Test		Positive		Full	Part	
	Members							

Appendices 3: Platform Analysis Result

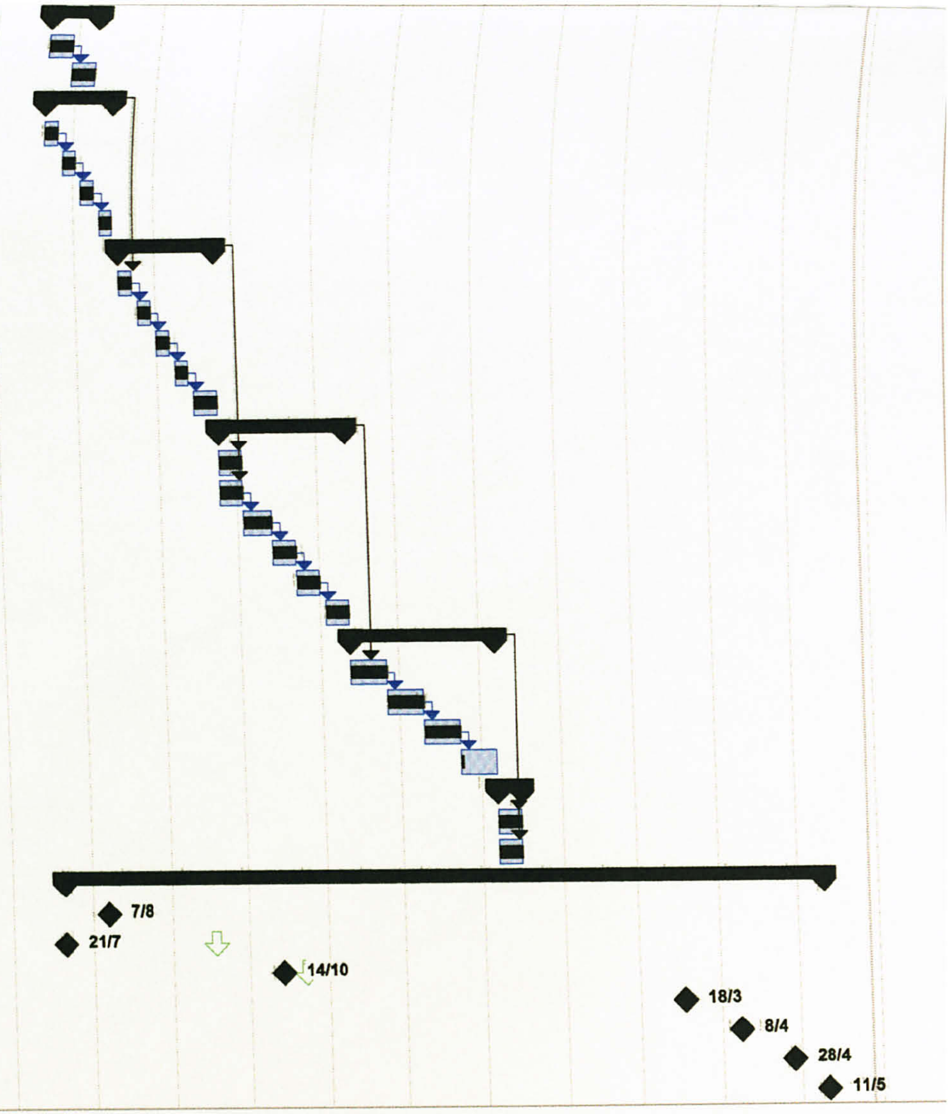
Analysis Details	
Platform Name	
Analysis Identification	
Analysis Year	
Analysis Type	
Analysis Software	
Analyst	
Analysis Description	

Analysis Information	
Drawings	
Weight Database	
Metocean Criteria	
Pile Data	
Electronic Model	
Model Plots	
Hard Copy	
Full Results	
Summary Results	

Analysis Data	
Caisson	
Conductors	
Risers	
Tide	m
Maximum Wave Height	m
Deck Elevation	m
Deck Load	MT
Marine Growth	mm
Scour	m
Conductor Subsidence	mm
Corrosion	mm
Damage Quantity	
Crack Quantity	

Item	Field	ID Platform	Risk ranking	Design Report	Design Drawings	Detailed assessment report	Static Inplace Analysis (SIA) Report	Inspection Report	SMR Report	Risk Ranking Spreadsheet	Fabrication Report	Photo	SACS Model	Provision of underwater inspection and maintenance service	Model Report	Oil Field dvlpmnt Envi. Dsgn Report	Structural Integrity Asessment Report	Inseervice Inspction Oil field Final report	ROV platform inpection Final Report	ROV and Side-scan Investigation	Trans & offshore inst of platform plines report	Technical Report, Simplified Structural Reliability Analysis	RBI Final Report	Detailed RBI analysis	Technical Rprt, Comprehensive Structural Reliability Analysis	Structural Reliability Analysis Final Report	Soil Boring	Shallow Gas study	Fatigue analysis	technical report	site visit report	struct eng review	Misc Struct design report	Cathodic Protection System	DD Package_Ranhill Worley	Remarks
1	Pulai	Pulai Drilling Platform A	VH	√	√	√	√	√				√	√	√					√				√			√	√	√							√	
2		Pulai Drilling Platform B	M			√																														
3	Ledang	Ledang Anua Drilling Platform										√																								
4	Tinggi	Tinggi Drilling Platform A	H			√																														
5	Bekok	Bekok Drilling Platform A	M																					√												
6		Bekok Drilling Platform B	L									√											√													
7		Bekok Drilling Platform C	M			√																														
8		Bekok-C Flare Jacket																																		
9	Tiong	Tiong Drilling Platform A	H			√																														
10		Tiong Drilling Platform B	L			√																														
11		Kepong Drilling Platform A	M			√																														
12	Duyong	Duyong Central Processing P	M																						√											
13		Duyong Gas Compressor Plat	L																																	
14		Duyong Drilling Platform A	L																																	
15		Duyong Drilling Platform B	M		√	√	√	√				√	√	√			√			√				√				√	√	√	√	√	√			
16		Duyong Drilling Platform C	L																																	
17		Duyong Living Quarter	M																					√												
18		Duyong Flare Jacket	M																																	
19		Sotong Collector Platform-A	M																																	
20	Resak	Resak Central Processing Platform																						√												
21		Resak Drilling Platform A										√												√												
22		Resak Flare Platform																																		
23	Dulang	Dulang Drilling Platform A	H																			√														
24		Dulang Drilling Platform B	H	√	√	√	√	√					√	√	√		√		√			√	√											√		
25		Dulang Drilling Platform C	H									√				√		√ √		√	√			√												
26		Dulang Drilling Platform D	H																				√	√												
27		FSO Puteri Dulang																																		
28	MASA	Malong Drilling Platform A	M																																	
29		Sotong Drilling Platform A	M									√																								
30		Anding Drilling Platform A	M																																	
31		FPSO Perintis																																		
32	Angsi	Angsi Drilling & Riser Platform A																						√												
33		Angsi Production and LQ A																						√												
34		Angsi Drilling Platform B										√																								
35		Angsi Drilling Platform C																																		
36		Angsi Drilling Platform D																																		
37		Angsi Drilling Platform E																																		
38	PNL	Penara Drilling Platform A																																		
39		North Lukut Drilling Platform A										√																								
40		FPSO Bunga Kertas																																		
41	Abu	Abu Drilling Platform A										√																								
42		FPSO Abu																																		

		Task Name	Duration	Start	Finish
1	✓	**Preliminary**	**14 days**	**Mon 21/7/08**	**Thu 7/8/08**
2	✓	Selection of Project Topic	7 days	Mon 21/7/08	Tue 29/7/08
3	✓	Research on Topic	7 days	Wed 30/7/08	Thu 7/8/08
4	✓	**Introduction**	**20 days**	**Mon 21/7/08**	**Fri 15/8/08**
5	✓	Background study	5 days	Mon 21/7/08	Fri 25/7/08
6	✓	Problem Statement	5 days	Mon 28/7/08	Fri 1/8/08
7	✓	Objectives	5 days	Mon 4/8/08	Fri 8/8/08
8	✓	Scope of Study	5 days	Mon 11/8/08	Fri 15/8/08
9	✓	**Literature review**	**27 days**	**Mon 18/8/08**	**Tue 23/9/08**
10	✓	General Oveview of Industry	5 days	Mon 18/8/08	Fri 22/8/08
11	✓	International Codes	5 days	Mon 25/8/08	Fri 29/8/08
12	✓	Structural Integirty Systems	5 days	Mon 1/9/08	Fri 5/9/08
13	✓	Natural Disasters	5 days	Mon 8/9/08	Fri 12/9/08
14	✓	Summary	7 days	Mon 15/9/08	Tue 23/9/08
15	✓	**Methodology**	**35 days**	**Wed 24/9/08**	**Tue 11/11/08**
16	✓	Literature Review	7 days	Wed 24/9/08	Thu 2/10/08
17	✓	Interview	7 days	Wed 24/9/08	Thu 2/10/08
18	✓	Data gathering	7 days	Fri 3/10/08	Mon 13/10/08
19	✓	Data Evaluation	7 days	Tue 14/10/08	Wed 22/10/08
20	✓	Strategy	7 days	Thu 23/10/08	Fri 31/10/08
21	✓	Program	7 days	Mon 3/11/08	Tue 11/11/08
22		**Result**	**40 days**	**Wed 12/11/08**	**Tue 6/1/09**
23	✓	Data Obtained	10 days	Wed 12/11/08	Tue 25/11/08
24	✓	Evaluation of Data	10 days	Wed 26/11/08	Tue 9/12/08
25	✓	Strategy for project	10 days	Wed 10/12/08	Tue 23/12/08
26		Program	10 days	Wed 24/12/08	Tue 6/1/09
27	✓	**Conclusion**	**7 days**	**Wed 7/1/09**	**Thu 15/1/09**
28	✓	Recommendation	7 days	Wed 7/1/09	Thu 15/1/09
29	✓	Future works	7 days	Wed 7/1/09	Thu 15/1/09
30		**Reports / Poster/Presentation**	**210 days**	**Mon 21/7/08**	**Mon 11/5/09**
31	✓	Submission of progress report 1	0 days	Thu 7/8/08	Thu 7/8/08
32	✓	Submission of interim report 1	0 days	Mon 21/7/08	Mon 21/7/08
33	✓	Presentation FYP 1	0 days	Tue 14/10/08	Tue 14/10/08
34	✓	Submission of progress report 2	0 days	Wed 18/3/09	Wed 18/3/09
35		Submission of poster	0 days	Wed 8/4/09	Wed 8/4/09
36		Final Presentation FYP 2	0 days	Tue 28/4/09	Tue 28/4/09
37		Submission of final report	0 days	Mon 11/5/09	Mon 11/5/09



Project: ProjectB.mpp
Date: Thu 28/5/09

Task | Split | Progress | Milestone | Summary | Project Summary | External Tasks | External Milestone | Deadline